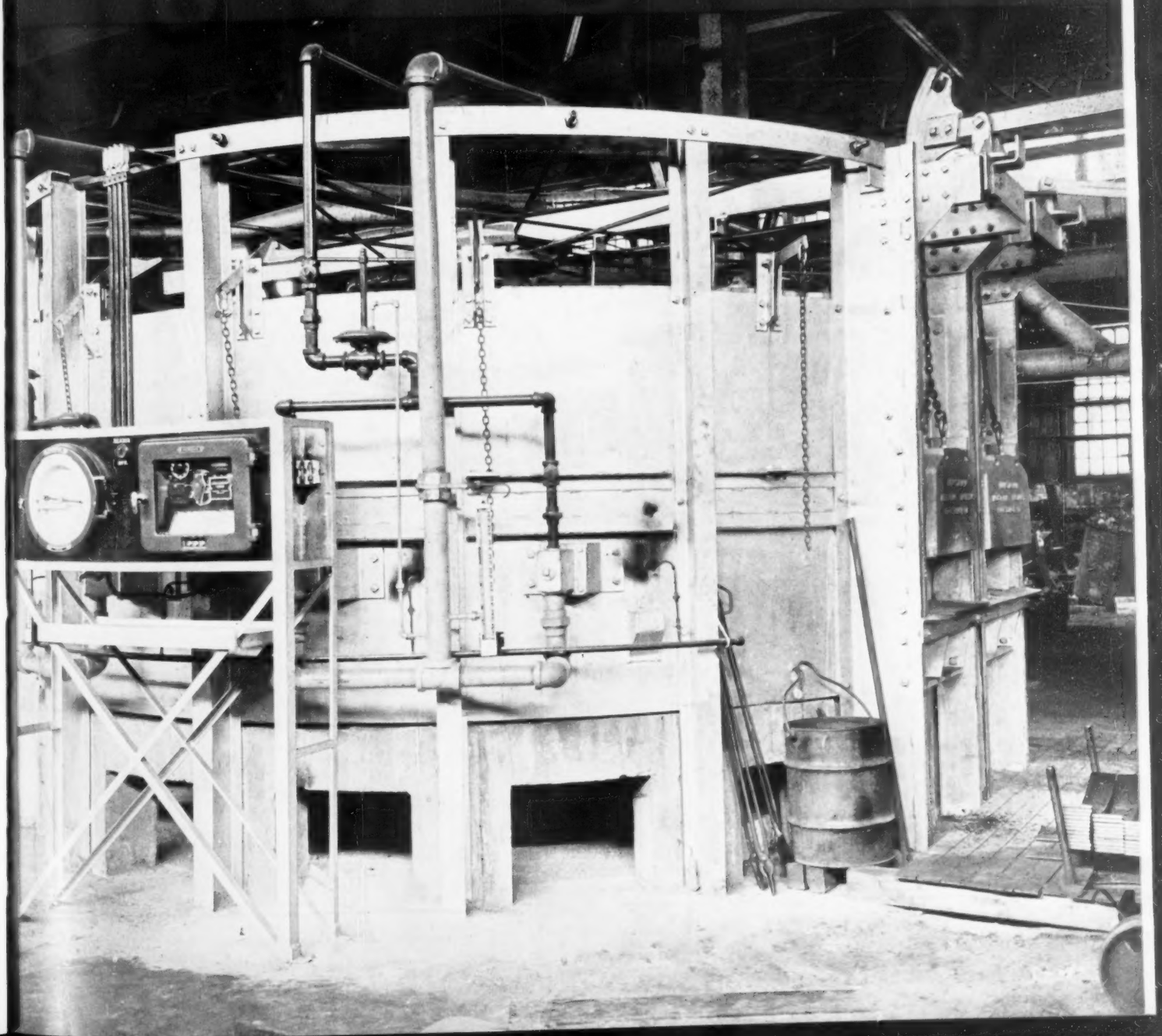
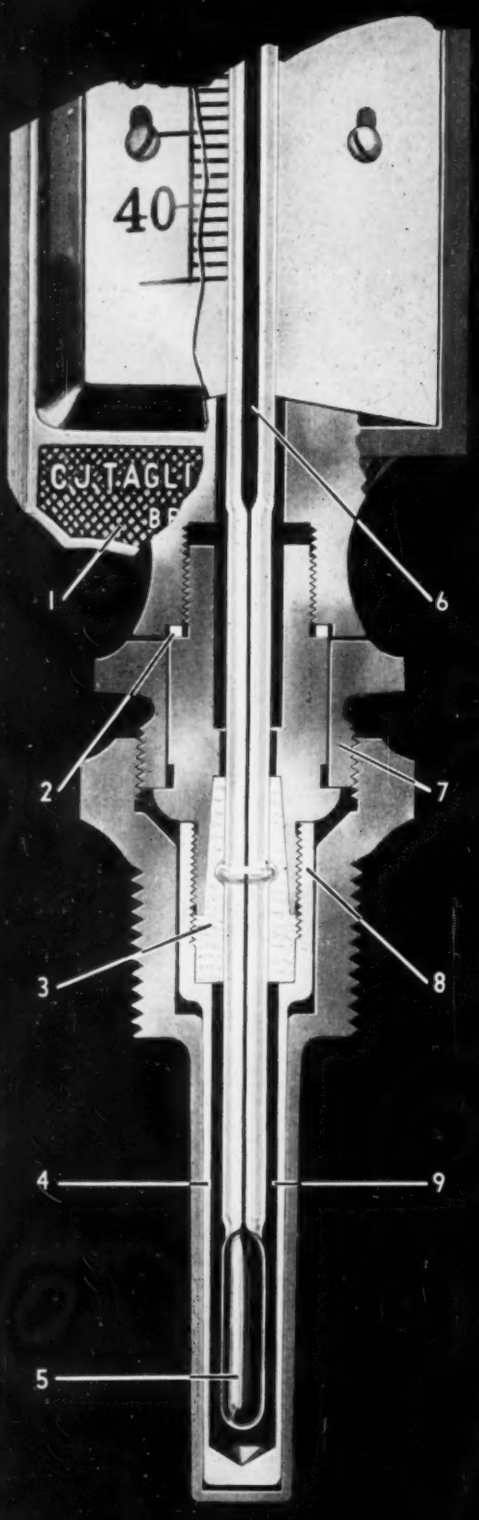
# Instruments

## THE MAGAZINE OF Measurement and Control

Vol. 11
AUG.
1938
No. 8



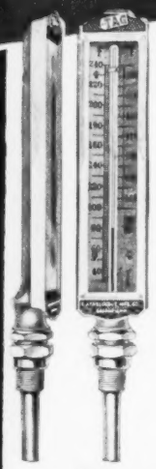
**SCIENTIFIC CONSTRUCTION and DESIGN IMPROVEMENTS have made TAG THERMOMETERS the Natural Choice of American Industry!**




Section of TAG Separable Socket Thermometer 2½ Inch Stem, ¾ Inch s.p.t.

# TAG

## INDUSTRIAL THERMOMETERS



Over a million TAG THERMOMETERS have been bough American Industry, which is ample evidence of the fact tha represent the highest state of perfection in design, constru and utility. Over the years, the traditional precision of TA DUSTRIAL THERMOMETERS has been steadfastly maint . . . in step with modern practice, many new and desirab provements have been made in these fine instruments.

## *Observe the many Outstandin Constructional Features*

1. The TAG Snap Case-Front, makes cleaning easy. A tongue at th top of the case fits snugly in a groove in the front. It takes litt effort to replace the front, which when on the instrument, is he firmly closed by the snap device. There are no screws to loosen, los or misplace.
2. Connecting piece locked to case by a specially designed split spring washer.
3. Asbestos packing, uniformly compressed around enlargement o glass stem prevents movement of tube with reference to scale.
4. The stainless steel bulb chamber is thin enough to allow quick con ductivity, yet rugged and non-corrosive . . . cannot amalgamate wit the mercury filling.
5. The bulb is specially seasoned and aged to prevent molecula changes in use. It is thin, yet so uniform, that it will not crack wit sudden temperature changes.
6. TAG Red-Reading Glass, with magnifying lens-front, is specia seasoned and guaranteed for permanent accuracy.
7. Coupling nut, revolving freely on stem of connecting piece for at taching Thermometer by means of a union or separable socke connection.
8. Left handed thread on bulb chamber prevents loosening if case i turned in removing Thermometer from socket.
9. Filling in bulb chamber completely surrounds bulb of Thermometer and insures quick transmission of heat.

Write us today for your FREE copy of the TAG INDUSTRIAL THER MOMETER Catalog No. 1125-I . . . 24 pages showing the complete line of these notable instruments. You will find it an asset to have on file.

**TAG Industrial Thermometers**

**GUARANTEE**

ACCURACY—Highest attainable.
CONSTRUCTION—Highest grade workmanship.
MATERIAL—Most durable for the particular application.

C. J. Tagliabue Mfg. Co

# C. J. TAGLIABUE MFG. CO.

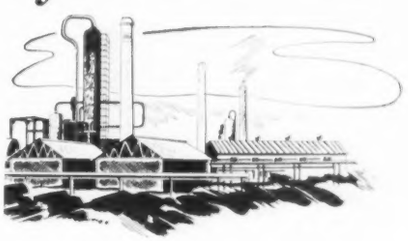
**PARK & NOSTRAND AVES.. BROOKLYN, N. Y.**

# CALLING ALL REFINERS!

## *to look at this record of control*

If you want proof of precise, money-saving control of temperature, pressure, flow and liquid level—

***then look into Taylor Control in modern refineries***



A 16,000-barrel-a-day *combination selective cracking unit* ran continuously for 34 days on its first firing. All guarantees of capacity and products were met, without a single barrel of off-specification products! Taylor Instruments provided the precise control of temperature and flow that helped make this record possible.

Another similar plant was designed to *operate on Mid-Continent and Corning* crudes. It ran continuously for 39 days on its first firing, making specification products at guaranteed capacity. Temperature, pressure and flow were—and are—Taylor-Controlled.

And still another. On an atmospheric-vacuum distillation unit in the Mid-Continent field, Taylor Systems maintained temperatures, flows and pressures within such close limits that the end points of the products were held more constant than were ever thought possible. This record led to specifications of Taylor Controls in four more atmospheric-vacuum units for four other oil companies.

*In solvent dewaxing,* Taylor Controllers maintain the outlet temperatures of double-pipe chillers in eight of the country's most modern plants. Other temperatures and pressures in the process are also Taylor-Controlled.

These are some examples of how Taylor Engineering, plus Taylor Instruments, has brought new high operating efficiency to refining plants today—how it has helped to cut costs and minimize production worries. Go into modern plants of leading companies. You'll see Taylor Systems providing precision control of temperature, pressure, flow and liquid level. The records show it.

What processes are you concerned with? Atmospheric distillation? Vacuum distillation? Combination atmospheric-vacuum distillation? Combination selective cracking? Solvent dewaxing? Recovery and stabilizing? Taylor engineers will bring to your particular problem thorough knowledge of refining processes. And the instruments Taylor engineers install are the finest of their type—in design, in workmanship, in the service they give.

To take advantage of the services of Taylor engineers—offered to you without charge—and to obtain further information about Taylor Instruments and Systems, get in touch with a Taylor representative. Or write to Taylor Instrument Companies, Rochester, New York, or the nearest local office. Manufacturers in Great Britain—Short & Mason, Ltd., London, England.

### DO YOU KNOW ABOUT THESE TAYLOR DEVELOPMENTS?

**FULSCOPE CONTROLLER** with the Universal Sensitivity Adjuster, the first graduated dial with infinite positions of sensitivity for obtaining the best throttling range for every job. An original Taylor feature.

**PRECISION VALVE ACTION.** Originally an inbuilt part of the Taylor Dubl-Response Control Unit, this was later made available in a separate unit, the Valv-Precisor.

**THERMOSPEED.** Taylor led the way in developing greater speed for tube system response when separable wells are used.

**ACCURATUS TUBING** permits use of all-steel welded tube system, automatically compensated, without loss of advantages of mercury as actuating medium. Until its introduction, mercury tube systems longer than 25 feet were unsuccessful. Now lengths one hundred feet and over are not unusual.

**MOTOSTEEL EVENACTION MOTORS.** Taylor was the first to use the all-steel welded valve motor, both stronger and lighter than older types.

**INDUSTRIAL THERMOMETER** with BINOC Tubing make temperature-reading easier . . . end guessing. BINOC Tubing provides 2 to 5 times greater visibility of the mercury column and eliminates bore reflections.

**Taylor**

Indicating / Recording Controlling

**TEMPERATURE, PRESSURE, FLOW** *and* **LEVEL INSTRUMENTS**

# Building Blocks
## FOR INDUSTRY

Some of the world's largest industries have built their success upon the precision of Johansson Gage Blocks. Accurate to ±.000008 inch, they are unexcelled by any other commercially available standards of measurement—yet priced within reach of the small shop worker. They are sold in sets or individually, separate blocks priced as low as $3.50. Foremen and shop owners should investigate also the low-priced accessory sets and the assortment of Adjustable Holders, which protect blocks and make handling easier. Get complete information by writing for Catalog No. 12 to Dept. D.

Johansson ACCURACY

**FORD MOTOR COMPANY**
JOHANSSON DIVISION
DEARBORN MICHIGAN

# Where accuracy is insured

*out in the field*

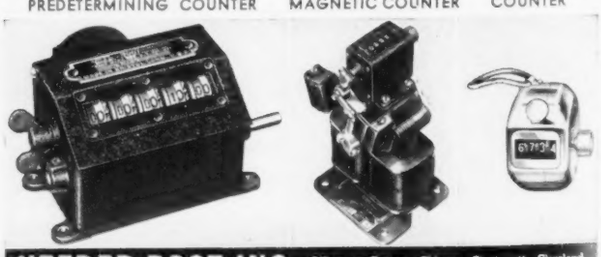
THE MAINTAINED in-built accuracy of Westcott orifice meters, whether for Indicating, Recording or Integrating, is embodied in: precision machining of differential gage body chambers . . . low angle of float travel . . . small angular travel of static pressure tube . . . only one movable part between mercury surface and chart record. • Information is available on request.

AMERICAN METER COMPANY
METRIC METAL WORKS *ERIE, PENNSYLVANIA*

# MEASURE and CONTROL
## with Veeder-Root Counting Devices

You can keep an accurate check on practically any machine or process with Veeder-Root Counters for mechanical, electrical and manual operation. These counters will provide daily records in any terms you want... operations, revolutions, strokes, pieces, trips, starts, stops, mileages, volumes, speeds, lengths, electrical impulses, etc. Find out what they can do for *you*. Write for complete information.

HIGH SPEED PREDETERMINING COUNTER | REMOTE INDICATING MAGNETIC COUNTER | HAND TALLY COUNTER

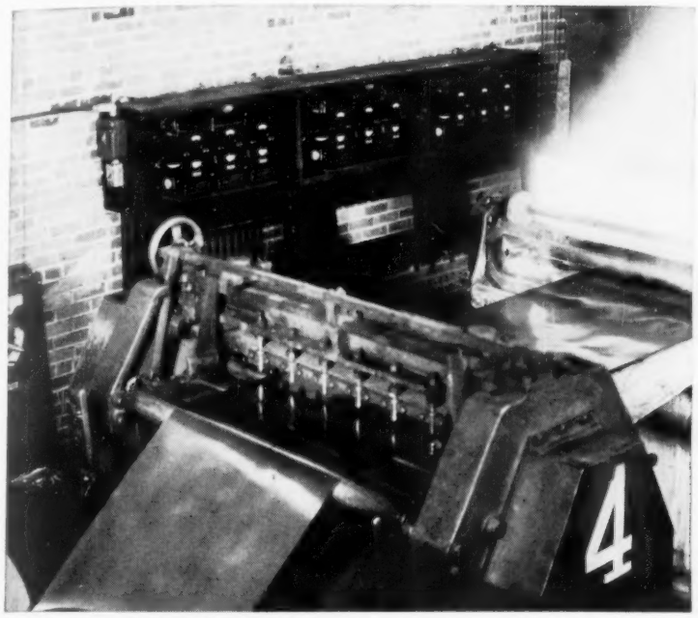


**VEEDER-ROOT INC.**
*Counting Devices*
HARTFORD, CONNECTICUT

Offices in Boston, Chicago, Cincinnati, Cleveland, Detroit, Greenville, S. C., Los Angeles, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco, Montreal, Canada, Buenos Aires, Mexico City, London, Paris, Tokio, Shanghai, Melbourne

# SEE FOR YOURSELF why Foxboro

## potentiometer controllers are so accurate and dependable



Battery of nine Foxboro Potentiometer Controllers for three electrolytic cleaning tubs in the Wheeling Steel Plant at Yorkville, Ohio.

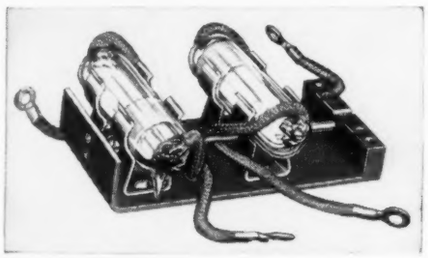
ACCURATE and dependable control is a fact with Foxboro in hundreds of installations, such as the one shown at the left. The slightest variation of temperature causes action, instantly, to restore the desired temperature. Initial cost is less . . . space is saved . . . and maintenance is materially reduced . . . particularly with the Foxboro Multiple Drive.

Some of the many reasons why an ever-increasing number of users is buying Foxboro Pyrometer Controllers are detailed on this page. They will help to explain why users say that no other controller can give you so much for so little. The Foxboro Company, 46 Neponset Avenue, Foxboro, Mass., U. S. A. Branch Offices in 25 Principal Cities.

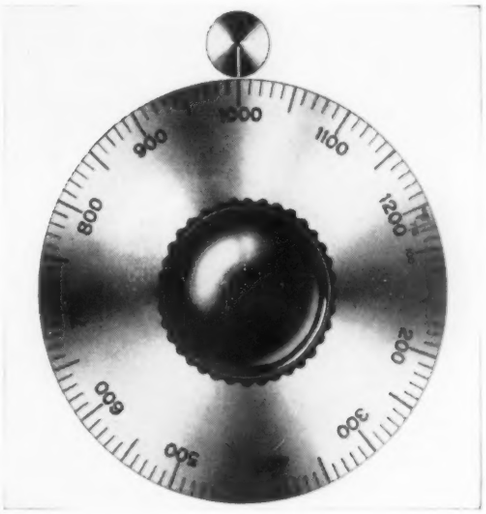
FOXBORO

REG U S PAT OFF

**POTENTIOMETER CONTROLLERS**



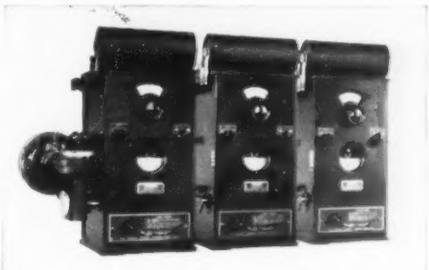
For the most economical and accurate operation for different requirements Foxboro provides two types of control contacts: mercury-in-glass type, and intermittent brush type. Foxboro engineers will gladly recommend the correct type for your specific conditions.




A 12-inch temperature scale is provided on the giant setting dial. Accurate setting is thus assured—an essential step in obtaining accurate temperature control.

All adjustments are outside on the Foxboro Controller. No oiling or attention inside the case is required. Control setting dial . . . mechanical zero adjustment . . . and standardized knobs are grouped conveniently on the front of the Controller.

Knife-edge selectivity is a feature of the Foxboro Controller. As little as two-thousandths of an inch of galvanometer point deflection will cause regulating action. Accurate temperature regulation is assured.



Economy of cost without reduction of efficiency is obtained by Group Drive. Foxboro Controllers may be lined up in batteries of as many as eight, and driven by one motor. See installation above.

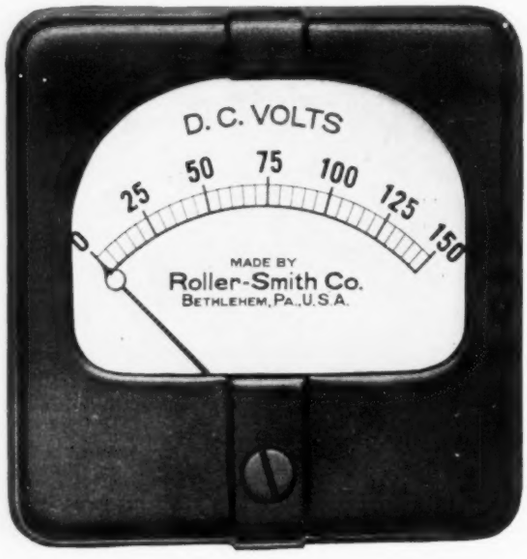
# ROLLER - SMITH

## Announces

# 3″ Square

### ALTERNATING AND DIRECT CURRENT

Ammeters, Milli-ammeters, Micro-ammeters, Radio Frequency Ammeters and Milli-ammeters; Voltmeters, Milli-voltmeters and special Instruments. Types TA, TD and TW. The line is most complete, comprising all ranges required in commercial and laboratory work. Case and base are black Bakelite.




These Types TA, TD and TW instruments are available also in **round** cases, 3½″ diameter.

Types FA, FD and FW instruments, 4″ diameter, are offered where a somewhat larger instrument is required.

Send for *New* Supplement 3 to Catalog J-48.

**ROLLER-SMITH COMPANY**
Electrical Measuring and Protective Apparatus

| MAIN OFFICE: | WORKS: |
|---|---|
| 2132 Woolworth Bldg., New York | Bethlehem, Pa. |

*Sales Agencies in Principal Cities in U.S.A. and Canada*



# *Instruments*

## THE MAGAZINE OF MEASUREMENT and CONTROL

VOL. 11 No. 8

**AUGUST, 1938**



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Published Monthly on the 15th by
THE INSTRUMENTS PUBLISHING COMPANY
1117 Wolfendale Street, Pittsburgh, Pa.

RICHARD RIMBACH, Managing Editor — M. F. BEHAR, Editor

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New York: R. K. Farnham, 118 E. 28th St. (Lexington 2-4637)
Chicago: William Farnham, 201 N. Wells St. (Andover 4180)
Cincinnati: E. Eggers, 3642 Brentwood Ave. (East 3174)
Philadelphia: R. K. Farnham, 1533 Cherry St. (Rittenhouse 2530)

Annual Subscription: U. S. $2.00. All other countries $3.00 *payable in advance* (remit by New York draft).


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Entered as second-class matter January 26, 1932, at the post office at Pittsburgh under the Act of March 3, 1879.

INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

## IN THIS ISSUE

In his first (May) article, Power Superintendent W. W. Dulmage described the boiler control instrumentation in the No. 1 Power Plant of the Ford Motor Co. His June article described the boiler feed instrumentation and last month he dealt with turbine instrumentation. In logical order he now describes the instrumentation of condensers and other equipment. He will conclude next month with the electrical instrumentation of the famous No. 1 Power Plant at Dearborn.

Professor Williams takes up further types of hardness testers using ball, pyramid and cone indenter and—as usual—not only describes but critically discusses the methods and their relative limitations.

The Scientific Apparatus Makers of America, association of instrument makers, has a history of useful achievement little known outside of that industry, but its Industrial Section has "started something" which will appeal to all instrument users. Five hundred dollars in cash prizes for descriptions of instrument applications! Twelve prizes in all! The great majority of *Instruments* readers, being users and not makers, are eligible. Read all about it opposite page 198.

## THE FRONT COVER

Within a half hour's drive from *Instruments*' office there are enough interesting installations for several years' front-cover illustrations. This month's is a close neighbor: at the Pittsburgh Spring and Steel Co. in Pittsburgh. Pyrometric equipment by Leeds and Northrup on furnaces by Pennsylvania Industrial Engineers (whose photograph we gratefully use).

*Last Month's Front Cover—Correction.* Our apologies for mixing up two Askania Regulator Co. soaking-pit control panel photographs which we had received together. The one used last month shows the control panel on one of the Combustion Engineering Corp.'s "One-Way-Fired" soaking pits at the Allegheny Steel Corp., Brackenridge, Pa.

# JOB SECURITY

DURING the depression of 1930-31-32 we had occasion to note that the jobs of measurement-minded engineers and operating men were more secure than those of others. When *that* depression ended, we commented in our March 1933 editorial:

Our readers constitute a group which—as appears from the small number of recent changes in our subscribers' list as compared to those of trade and technical journals in general—is exceptionally stable, remarkably secure, unusually "certain" of better days. After all, those who specialize in the measurement and control of physical variables should best be able to control some factors affecting their own status!

A year ago another depression struck Industry. Job-seekers enlisting our services in the last twelve months numbered about one-tenth of the total for any twelve months in 1930-31-32. They numbered no more than the total for the boom year ending in the summer of 1937!

However, the fact that one is "an instrument man" does not automatically make one's job secure. We pointed this out in our March 1933 editorial and we repeat it now:

As the great ones proclaim, the depression is definitely over. "Consequently," rejoices the individual technical man, "consequently *my* outlook is brighter; consequently *I* personally must benefit." Such reasoning is faulty. It isn't even reasoning: it is day-dreaming. Few individual workers, whose security depends on their personal abilities, have any valid reasons for mathematical certainty as to their own futures. The world has never owed even a bare living to every individual one of us slide-rule users.

What is the answer? You know it: *Personal preparedness. . . .*

## INSTRUMENTATION RECOGNIZED BY ENGINEERING SCHOOLS

### *Two Significant Items*

**1. M.I.T. Summer Ceramic Program, July 18-22**

(REPORT)

Attended by research directors, engineers and operating executives of companies manufacturing glass, whitewares, refractories, bricks, tile and other ceramic products, a one-week advanced course on heat technology was held at the Massachusetts Institute of Technology, Cambridge, Mass., July 18-23 under the direction of Professor F. H. Norton. The first morning was devoted to a lecture on the Measurement and Control of Temperature by Major M. F. Béhar, editor of *Instruments* magazine, Pittsburgh, Pa. An Instrument Exposition organized by Major Béhar was held in the Heat Laboratory that same week. The newest pyrometers and temperature controllers were displayed by sixteen instrument-making firms and studied each afternoon by one-fifth of the class. Both the "Temperature" lecture and the temperature-instrument exposition were attended also by engineers taking other summer courses at the Institute.

**2. Steel Instrumentation Conference, October 13-14.**

(ANNOUNCEMENT)

Plans have been formulated for a conference on Instrumentation in the Steel Industry, sponsored by and held at the Carnegie Institute of Technology, Pittsburgh, Pa., on October 13-14, 1938. The purpose of this conference is to bring about a better knowledge of the advances made in measurement and control in the steel industry. Richard Rimbach, Supervisor Extension and Evening Courses, Metallurgical Department, Carnegie Institute of Technology, is in charge of arrangements for the Conference. For further details write Prof. Rimbach.

# THE MONTH'S NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

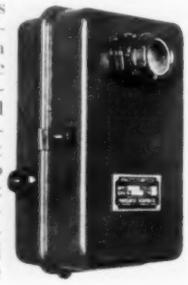
Or write to Information Section, Instruments Publishing Company.

## Vitreous-enameled Rheostat

New "Model P" 225-watt rheostat fills in between maker's 150- and 300-watt units, employs same all-porcelain and metal type of construction with resistance wire wound on a solid porcelain core and rigidly held in place, insulated and protected by Ohmite Vitreous Enamel (see *Instruments*, April 1932, page 108; March 1937, page 63). "Model P Rheostat-Potentiometer" is regularly supplied with a $3\frac{1}{4}$" diam. Bakelite handwheel. Dimensions: $2\frac{1}{8}$" mounting depth by 5" diam. Available in a wide range of resistance values, in single or tandem assemblies.—*Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago, Ill.*

## Photoelectric Smoke Density Equipments

Several smoke control devices are announced, including light sources, photoelectric density measuring units, housings with glass windows removable for cleaning, time meters for totalizing periods of excessive density, etc. Illustration shows photoelectric unit of "Photoswitch Control Type A20C." Adjustment knob at left may be set to close signal circuit at any predetermined smoke density. This unit and light source are ready to use on 110-volt a-c. supply.—*Photoswitch, Inc., 21 Chestnut St., Cambridge, Mass.*

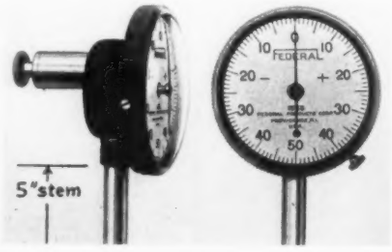


## Laboratory Furnace

Capable of continuous operation at 3000°F., "Hi-Temp Tubular Glo-bar Combustion Furnace" has been developed for such uses as carbon or sulphur determinations in ferrous and non-ferrous metals, testing high-alloy steels, heating specimens in temperatures from 500 to 3000°F. Tubular Glo-bar element has 2" inside diam. Overall length of standard "Hi-Temp Combustion Furnace" is $19\frac{1}{4}$"; others available up to 30". Temperature is controlled manually by a step voltage transformer or automatically by a pyrometer controller.—*Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich.*

## Back-spindle Indicator

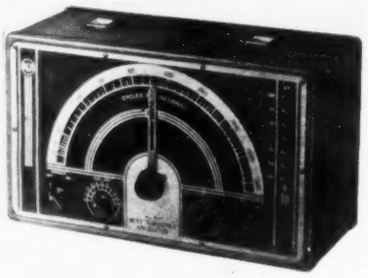
New "V-8-I" Indicator, graduated in 0.001" and with a range of 0.1", is of the perpendicular spindle type, permitting convenient use in positions where regular type is not readily adaptable.




Improvements in design and construction include elimination of friction by substituting a crown gear for the previous spiral, and by use of "Oilite" bushing (self-lubricating bronze).—*Federal Products Corp., 1144 Eddy St., Providence, R. I.*

## Beat Frequency Audio Oscillator

Among features of new "No. 154" beat-frequency audio oscillator are: overall distortion of less than 5% over the entire range from 30 to 15,000 cycles,



complete a-c. operation, RCA metal tubes, high output, large easy-to-read dial, and an output frequency ± 1 db. from 30 to 10,000 cycles, down to 2 db. at 15,000 cycles. Instrument weighs 15 lbs.—*Parts Division, RCA Mfg. Co., Camden, N. J.*

## Three-inch Square Panel Instruments

Supplementing maker's larger and smaller lines, a new line of 3" × 3" flange instruments (with $2\frac{3}{4}$" body diameter and $1\frac{3}{8}$" body depth) is announced. It includes "Type TD" d-c. ammeters, milliammeters, microammeters and voltmeters; "Type TA" a-c. ammeters, milliammeters and voltmeters; "Type TW" thermocouple ammeters and thermocouple milliammeters. Scale length is 2.1"; case material is black molded Bakelite; mounting requires one $2\frac{1}{8}$" hole and two screw-holes; electrical-instrument specifications are otherwise identical with those of "Types TD, TA and TW" but surface-mounting instruments are not available, these being flush-mounting instruments.—*Roller-Smith Co., 2132 Woolworth Bldg., New York City.*

## Welding Timers

New Ignitron spot welding timer, "Type SP-11," will mount two sizes of Ignitron tubes. On low-duty cycles, the WL-652 tube will carry 1500 amps at 220, 440 or 550 volts, while the WL-651 will carry 2800 amps at 440 and 550 volts or 4300 amps at 220 volts. Current rating is decreased at higher duty cycles above about 3.5%. Ignitron timers are adjustable to pass current for any exact number of cycles from 1 to 15. For longer times, the SP-11-A is adjustable from 1 to 30 cycles. Welding machine current starts and stops at current zero eliminating line current transients.—*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

## Automatic Timer

"Sentinel Electric Appliance Control," though developed for household electrical appliances, appears to be suitable for timing industrial plant and laboratory devices on 110-volt 60-cycle supply drawing up to 15 amps. It has two clock-like timing dials (for "on" and for "off" times) and a 4-point main control knob ("manual," "off," "on" and "set"). In operation, therefore, it closes a circuit at a predetermined time and opens it at another predetermined time; or it does both with one setting; or it performs either operation alone.—*American Time Corp., Geneva, Ill.*

## Vacuum . . . Thermocouples

Ranges from 1 milliampere to 10 amperes, in either contact or separate heater types. Prices from $3.00, quantity discounts.

*Write for Bulletin "A"*

**AMERICAN Electrical Sales Co. Inc.**
67 E. 8th St. New York, N. Y.

## S-M-O-O-T-H VOLTAGE CONTROL for A.C. circuits

The Type "TH" Transtat is the new continuously variable auto-transformer regulator . . . the ideal voltage control for a.c. circuits. It offers high efficiency, good regulation, great flexibility and dependable construction at moderate cost. Standard types are available for controlling voltage to single-phase and polyphase loads rated 10 Kva. and smaller, 50 or 60 cycles, 115, 230 or 460 volts. May we send you bulletin 51-1 which contains complete data?

TRANSTAT
VOLTAGE REGULATORS

**AMERICAN TRANSFORMER CO.**
178 Emmet St. Newark, N. J.


## Hand Tachometer

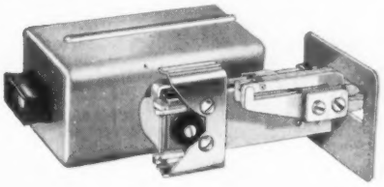
New "O-Z Improved Hand Tachometer with Fixed Reading Device" features a push-button device whereby the pointer is fixed at the indicated speed, thus enabling user to read conveniently an indication taken on a machine part difficult of access or poorly illuminated. Ranges (selected by knurled knob): 40-500, 400-5000 and 4000-50000 r.p.m.; and also six f.p.m. ranges from 12 to 25000. Scale with only one set of numerals for all ranges is said to be a further convenience. Mechanism requires no oiling, gives dead-beat indications. Tachometer weighs 1 lb. (1½ lb. in carrying case with accessories). Dial 2¾" diam.—*O. Zernickow Co., 15 Park Row, New York City.*

## Film Slide Viewer

Film slide viewer has been developed for miniature camera work, enabling worker to study his negatives for enlarging possibilities, etc. Ground glass diffusing screen is approx. 2" × 2", permitting showing all popular miniature sizes. 3" lens produces a crisp enlarged image and creates an illusion of depth. Viewer operates on 110-volt a-c. or d-c., uses standard 15-watt Mazda bulb. Housing is well ventilated, is finished in brown, green or black.—*Bausch & Lomb Optical Co., Rochester, N. Y.*

## Rapid-operation Relay

New "Type C" fast-operation fast-release relay can be furnished for voltages up to 220 and in wattage ratings depending largely on contact materials, of which



maker offers a choice: silver, palladium, platinum-iridium, tungsten or $\frac{1}{16}$" laminated steel silver. Can be arranged with various contact assemblies up to 32 springs per relay. Design and construction make new relay particularly suitable for electronic, industrial and meter control applications as well as for remote-indicator applications. Cover is one-piece aluminum slip-on type.—*C. P. Clare & Co., 4541 Ravenswood Ave., Chicago, Ill.*


BAILEY METER CONTROL SYSTEM

## *The Mark of* Effective Control

**Process Control** for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

**Combustion Control** that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

*Recorder-Controller*

**Boiler Meters** for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

**Multi-Pointer Gages** for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.

*Control Drive*

**Flow Meters** for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

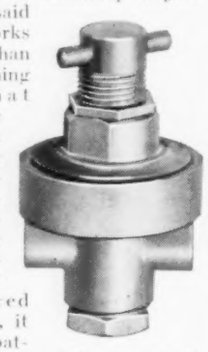
**Recorders** for pressure, temperature, drafts, liquid level and other factors.

G-3

**BAILEY METER COMPANY**
**1041 Ivanhoe Rd., Cleveland, Ohio**

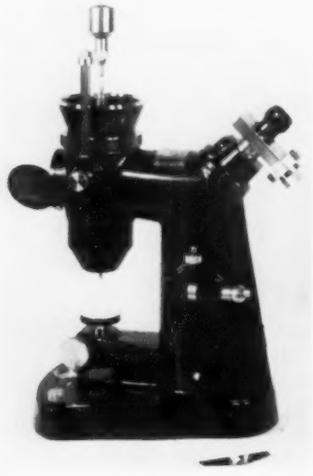
## Air Pressure Control

For reducing and stabilizing air pressures, new "Model 38 Midget" regulator employs a cloth-impregnated rubber diaphragm loaded by a manually adjustable spring. It is said that "the seat works with, rather than against, the incoming pressure" and that this permits the employment of a semi-soft seating material which prevents creepage because foreign particles lodging in the seat are embedded by the nozzle pressure. Improved design is due also, it is said, to "the patented Dockson process of die-casting alloys into finished regulator parts." In addition to ¼" female -thread side-inlet and side-outlet model illustrated, others are available, with or without pressure gages, brackets, etc.—*C. H. Dockson Co., 2857 East Grand Blvd., Detroit, Mich.*



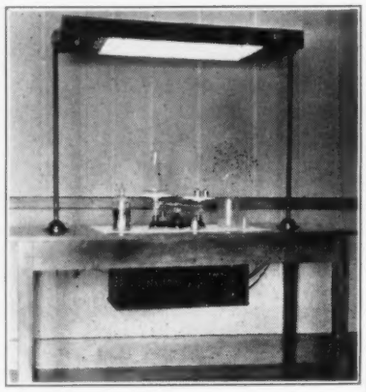
## Spherometer with Thickness Gage

New precision spherometer and thickness gage has a vertical measuring piston with a measuring range of 30 mm. which can be used for both spheric and thick-



ness measurements. Counterweight in interior of column gives uniform measuring pressure, and air damping is provided for the measuring pin. (Speed of piston can be adjusted at will.) Object table, 40-mm. diam., is of hardened steel, accurately ground and polished, has height adjustment. Measuring piston scale is of glass, graduated to 0.001-mm. precision. Micrometer screw pitch is 0.5 mm. 45° inclined eye-piece and pleasant green illumination facilitate reading. Micrometer drum has 100 divisions, each corresponding to a 0.001-mm. movement of measuring piston. For spherometric testing, hardened steel rings can be furnished in 1.2-, 2-, 3-, 5-, 8-, 15-, 25-, 35-, 50-, 65-, 80-, and 120-mm. sizes. Instrument weighs 23 lbs.; rings come in a separate box, gross weight 9 lbs.—*American Askania Corp., 826 M. & M. Bldg., Houston, Texas.*


**BARKON COLOR MATCHING LAMPS**



Barkon Carbon Dioxide Lamps provide a technically accurate artificial daylight—do not change with age—a standard light source.

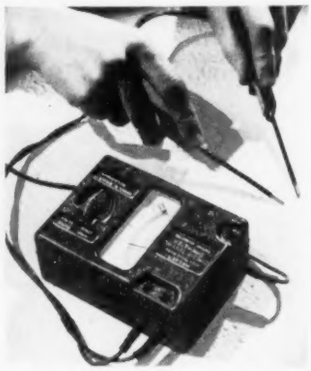
*Write for Literature*

**BARKON-FRINK Tube Lighting Corp.**

Long Island City New York



**MIDGET "MEGGER" CIRCUIT TESTING OHMMETER**



**Independent of Battery Voltage**

**Ranges—from .1 ohm up to 200,000 ohms**

Quite different from a voltmeter calibrated in ohms, this direct-indicating "Megger" Ohmmeter requires no adjustment for the voltage of the battery that supplies current for the test. The instrument is a true ohmmeter of the "Megger" cross-coil type. For laboratory, shop and portable use for checking coils, resistors, contacts, windings, circuits, relays, etc., and even insulation resistance up to 200,000 ohms. Molded case, mottled green in color. *Write for descriptive Bulletin 1495-I.*

**JAMES G. BIDDLE CO.**

ELECTRICAL INSTRUMENTS

1211-13 ARCH STREET PHILADELPHIA, PA.

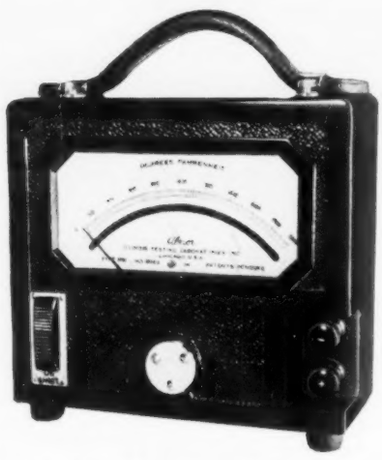

## Frequency Standard

A small, portable, economical frequency standard for most laboratory checking and calibration purposes where extreme accuracy is not required, "Model

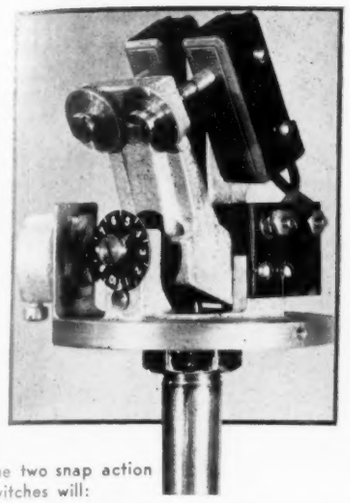
33 Calibrator" contains three crystal-controlled oscillators having fundamental frequencies of 100, 1,000 and 10,000 kc., arranged to generate harmonics usable up to about the 30th or 40th of each crystal fundamental. In addition, there is a multivibrator controlled by the 100-kc. oscillator, giving fundamentals of 50, 25, 20 and 10 kc., the harmonics of these being usable up to about 3,000 kc. so as to provide finer subdivisions of the main frequency intervals. The three crystals are ground and adjusted to an accuracy of 0.01% and it is said that temperature error will not exceed this value, giving limit of error of 0.02% under normal conditions.—*Ferris Instrument Corp., Boonton, N. J.*

## Shock-proof Pyrometric Instrument

"Portable Pyrometer Type 3091" is a newly-developed 5" scale millivoltmeter having its movement spring-suspended within the outer case to minimize effects



of shocks. Movement itself has pivots and jewels designed and constructed to resist shocks. A pointer lock, said to be of a new type, damps relative displacements when instrument is transported. Heavy metal case and shatter-proof glass prevent breakage in event of instrument being dropped.—*Illinois Testing Laboratories, 420 N. La Salle St., Chicago, Ill.*



The two snap action switches will:

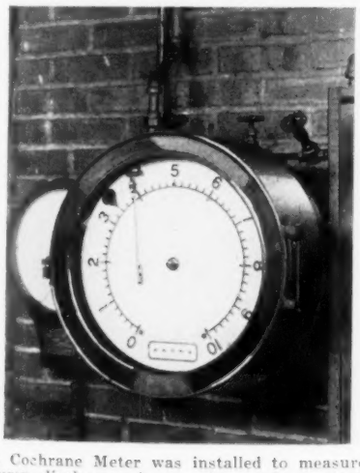
A. Control heating or cooling or both.
B. Control the temperature and give either a high or low limit device.
C. Give either two or three step control.
D. Give floating control with reversing control motors.
E. Give two or three speed control of auxiliary motors.

Available for temp. —100 to 1400°F. Other models with special alloy tubes suitable up to 1800°F.

*Send for particulars*

**BURLING INSTRUMENT COMPANY**
239-241 Springfield Ave., Newark, N. J.

## Cochrane Flow Meter Reduces Losses 40% by Detecting Leaks



A Cochrane Meter was installed to measure pump discharges in a water works system. A steady flow, recorded between 1 A. M. and 4 A. M., indicated leakage. This remedied, pumpage losses were reduced 40%. Savings were sufficient to pay for the meter **every two months.**

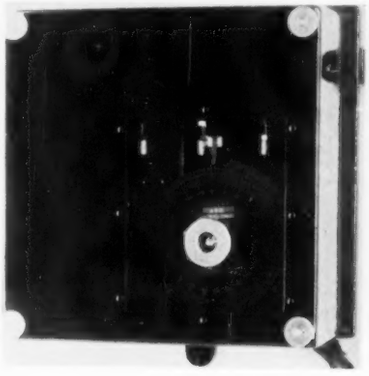
Cochrane Flow Meters give **accurate** measurements of fluid flow; dependable records and checks on operating costs. Write for illustrated bulletins.

**COCHRANE CORPORATION**
3120 N. 17th Street Philadelphia, Pa.

**COCHRANE**
FLOW METERS

## Air-operated Cycle Controller

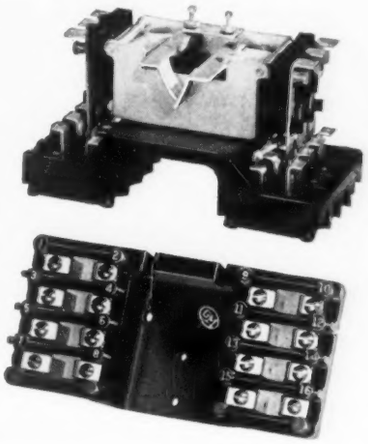
A new single-cam cycle controller that provides for the control of as many as four separate operations has been developed for process manufacturing, as



in vulcanizing rubber products and in plastic molding. Single cam is designed to be cut to suit requirements, and adjustable segments provide additional flexibility. Special operating mechanism makes it possible to obtain two different speeds of rotation before cam completes a cycle. Three-way leakless pilot valves obviate need for a fixed air leak at the controller. Cases are moisture- and dust-proof; motor and control switches are enclosed.—*The Bristol Co., Waterbury, Conn.*

## Twin-latch Relay

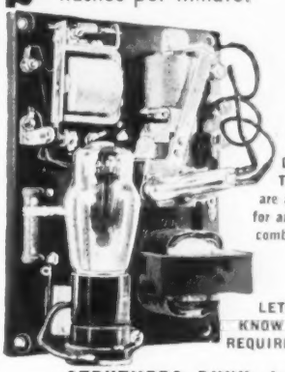
Newly standardized "Type L" twin-latch relay carries loads up to 30 amps. a.c. and 10 amps. d.c., requires 8 watts for operation, is suited for use in 3-wire



thermostatic control systems, or operations where circuits are closed with extremely light pressure or with slow movements. Consists of two coils and two hinged armatures, each of which carries a latch arm. Latch arms interlock, thereby mechanically holding one armature in energized position until other armature operates. Chassis is of molded Bakelite. Unit meets electrical code requirements up to 250 volts. Overall dimensions 5⅝" × 2⅞" × 2⅜" high.—*G-M Laboratories, Inc., 1752 Belmont Ave., Chicago, Ill.*

## *For* FLASHING of LIGHTS on a Continuous Cycle

This Dunco type TD-247 Electronic Time Delay is of the repeating type designed to flash lights at the rate of 40 flashes per minute.



Dunco Timers are available for any timing combination.

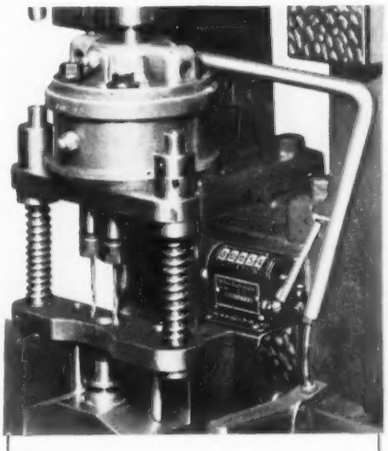
LET US KNOW YOUR REQUIREMENTS

**STRUTHERS DUNN, Inc.**
125 N. Juniper St. Philadelphia, Pa.

**DUNCO** *Electronic Type* **TIMERS**



*also* Motor Driven Thermal Air Dash Pot Instrip and Capacitor Types



## Check Production with Work Fixture Counters

Small parts production can be checked off with much time saved by having counters permanently attached to work fixtures. This fixture mounts on a drill press for drilling two holes in a pinion blank at one stroke. A *Productimeter* registers directly the number of blanks drilled.

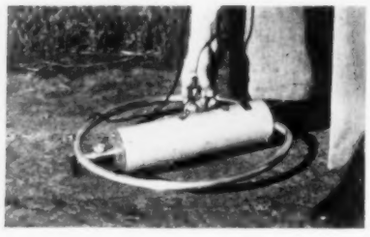
**DURANT MFG. CO.**
1930 N. Buffum St., Milwaukee, Wis.
182 Eddy Street, Providence, R. I.

*Sales Offices in all principal cities*

TELL US WHAT YOU WANT TO COUNT

## Buried Pipe Detector

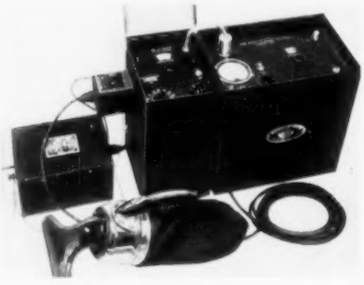
New pipe-line detector has been designed for an unskilled person to operate. Through its use an underground line can be identified promptly, according to maker, and followed without confusion resulting from close parallel



lines, crossings, etc. Operator walks out a line by simply carrying complete unit in one hand with earphones attached. The line is said to be easily followed by the signal coming through the earphones; laterals identified by the presence of a distant signal taking off to one side of the main line; and swedges by sudden decrease in signal strength when the pipe line decreases. Holding instrument horizontal and close to ground (see illustration) and moving back and forth over location first identified in walking out the line, signal will completely disappear when receiver is directly over pipe. A spear then driven in ground will directly locate the pipe. Instrument with earphones weighs 7 lbs. Transmitter with batteries to connect to line to give out signal, complete with two spears and leads for connecting to line, weigh 10 lbs.—*Seismograph Service Corp.* and *Engineering Labs., Inc., Tulsa, Okla.*

## Radio Noise Meter

New "Model L-C" radio noise meter makes it possible for electrical manufacturers and electric power companies to secure quantitative data on radio noise developed by electrical appliances and distributors on electric power circuits. It is a self-contained, battery-operated in-



strument conforming to specifications of Joint Coordination Committee on Radio Reception of NEMA, EEI and RMA. Supplied complete with 5-amp. power line Filterette which isolates test circuit from power supply line and is provided with three coupling units comprising correct values of resistance and capacitance to permit measurement of symmetrical and asymmetrical radio noise voltages at line impedances of 600 and 7500 ohms.—*Tobe Deutschmann Corp., Canton, Mass.*


**KNOW—DON'T GUESS**

*The Engelhard Portable Pyrometer*
The quality of your product or the production you may obtain may depend upon accurate temperatures. Economy demands instruments of reliability. Use the ENGELHARD Portable Millivoltmeter Pyrometer to protect your product and your production.

**Charles Engelhard, Inc.**
90 CHESTNUT ST. NEWARK, N. J.
Manufacturers of Pyrometers, Resistance Thermometers, Exhaust Gas Analysers, Flue Gas Analysers, Thermocouples.

**SOLENOID VALVES**
for Air, Gas, Oil, Water, Steam, Chemicals
SPRAY NOZZLES
For Humidifying and Air Washing
Home & Industrial Humidifiers
**Supreme Electric Products Corp.**
99 Mt. Hope Ave. Rochester, N. Y.

*The All Purpose*
**AIR VELOCITY METER**

*"Alnor" Velometer*
Instantaneous Direct Reading
No Timing
No Calculations
Write for Literature
ILLINOIS TESTING LABORATORIES, Inc.
142 W. Austin Ave. Chicago, Illinois

**NEW "ALNOR" PORTABLE PYROMETER**

Shock Resisting, Floating Movement, Has 5" Mirrored Scale Metal Case.
*Write for Details*
ILLINOIS TESTING LABORATORIES, Inc.
142 W. Austin Ave.
Chicago, Illinois


## Signal Generators

New "Model 17" and "Model 18" Universal Signal Generators both have five output selections: frequency-modulated r-f., amplitude-modulated r-f., unmodu-

lated r-f., 100- to 10,000-cycle continuously-variable a-f., and 400-cycle fixed audio output. All ranges are controlled by output attenuator. Both models provide synchronized horizontal sweep voltage for oscillograph. Frequency-modulated output (30-kc. sweep) is available over entire range of signal generator for visual alignment and trouble shooting, and is automatically disconnected when using amplitude modulation. Output voltage from 1 to over 100,000 microvolts on all ranges. Total length of direct-reading frequency scales (100 kc. to 30 Mc.) exceeds 100" and gives accuracy better than 1%. Both generators are alike except that Model 18 (illustrated) has a self-contained power level meter with three db ranges: —10 to +6, +6 to +22, +22 to +38.—*The Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio.*

## Two-inch C-R Tube Oscillograph

Cathode-ray oscillograph "No. 151-2," with special tilt mounting of tube to assure easy reading, has a deflection of 0.5 rms volt per inch at maximum gain.

In addition to this high sensitivity, its new tube is said to produce a bright image at low voltages. Instrument incorporates panel beam centering controls, vertical and horizontal amplifiers and internal saw-tooth sweep frequency. It may be used in conjunction with the RCA "9595" battery oscillator, with the new "154" a-c. oscillator when modulated by a frequency modulation, or with the "150" Electronic Sweep Test Oscillator.—*Parts Division, RCA Mfg. Co., Camden, N. J.*

**TEST MAGNETIC PROPERTIES OF YOUR STEELS**

**RAWSON FLUXMETER**

SIMPLEST AND MOST EFFICIENT
*Bulletin 504*

Dynamometers, wattmeters, milliammeters and voltmeters. Also ultra-sensitive meters both for A.C. & D.C., fluxmeters, electrostatic voltmeters from full scale 120 volts to over 20,000 volts, thermocouples, earth current meters, cable testers, etc.

*Acknowledged leaders in development of high sensitivity meters*

**RAWSON Electrical Instrument Co.**
CAMBRIDGE, MASSACHUSETTS
15 E. 26th St., New York
1313 W. Randolph St., Chicago
*Special Apparatus Built to Order*



**OFFICIAL COTTONSEED OIL SAMPLER**

+ + +

This sampler is constructed to meet A. O. C. S. specifications.

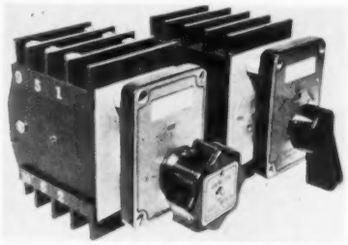
1. Uniform inside diameter of 2 inches and 10 feet long.
2. Remains fully open as it passes through the oil and closes only after the bottom of the tank is reached.
3. A smooth inside finish so as to prevent accumulation of dirt and moisture and facilitate cleaning.
4. Light and well balanced so that the sample may be taken vertically without difficulty.
5. So constructed that the sample can be obtained to within $\frac{1}{4}$" (or less) of the bottom of the tank.

*Write for Descriptive Folder*

**THE REFINERY SUPPLY CO.**
631 E. 4th St. Tulsa, Okla.


## Rotary Switches

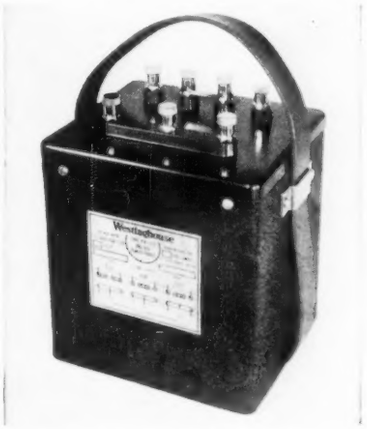
Supplementing "Type R" (*Instruments*, July 1934, page 144) new "Type R-2" line represents not only improvements and refinements but the widest



possible range of applicability. A typical instrument switch is shown at left of illustration, a control switch at right. Not shown is the "auxiliary" type which is similar to instrument switch except that position locator and face plate are eliminated and handle is replaced by an operating arm. All switches are easily mounted on panels of any thickness (which should be specified). In all types, thermal capacity and interrupting capacity are greatly in excess of normal requirements. Thousands of combinations of contacts, cams, stages, etc., are available.—*Roller-Smith Co., 2132 Woolworth Bldg., New York City.*

## Voltage Transformers

New "PV-130" portable voltage transformers are suitable for all portable instruments, recorders and laboratory applications in delta connection except for standards. Under ordinary conditions of load and power factor, accuracy is ± 0.25% on ratio and 20 minutes on phase angle. When used with special test data,




ratio may be corrected to within 0.1% and phase angle to within 3 minutes. Designed for 115-volt secondary, new transformers are available in two sizes: (1) Small, for primary voltages up to 2300 volts; weight 24 lbs.; dimensions $5\frac{3}{4}$" × $7\frac{1}{16}$" × $7\frac{1}{4}$". (2) Large size for primary voltages from 2300 to 6900 volts weighs 48 lbs., measures $7\frac{3}{4}$" × $9\frac{3}{16}$" × $9\frac{1}{8}$". Construction is shell type. Terminals, mounted on clearly marked Moldarta terminal block (which forms top panel) are made of bare polished nickel to preclude any assumption concerning their insulation.—*Westinghouse Elec. & Mfg Co., East Pittsburgh, Pa.*

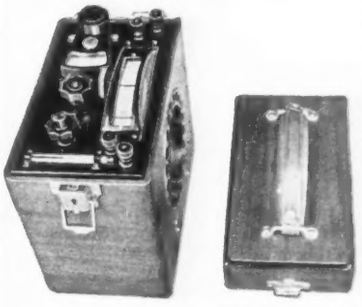

**WHEATSTONE BRIDGE**

A high-grade laboratory instrument containing 4 rheostat decades of 9 coils each, total resistance 9999 ohms, and a ratio dial affording 7 ratios, .001 to 1000. Rheostat coils are guaranteed accurate to within 1/10%, ratio coils to within 1/20%.

Described in Bulletin 100 which also describes Rubicon resistance standards, shunts, resistance boxes and several types of Wheatstone and Kelvin Bridges.

**RUBICON COMPANY**
*Electrical Instrument Makers*
29 North Sixth St. Philadelphia, Pa.





*"Sales Mean Jobs"*

**WHEELCO**
**Portable Potentiometer**
*with removable cover*

- Specially designed for field and laboratory use.
- Hand drawn millivolt scales, or temperature scales in Fahrenheit, Centigrade, or both.
- Accuracy and sensitivity is far higher than any temperature calibrated pyrometer.
- Made in four different models, having special equipment for different classes of service work.
- Complete data and information furnished on request.

*Write for Catalog "G"*

**Wheelco Instruments Co.**
1933 So. Halsted St. Chicago, Ill.

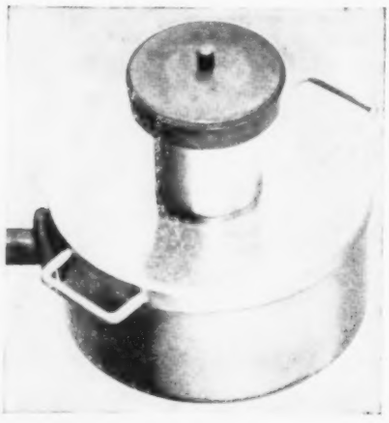
## Condenser and Resistor Testing Bridge

New Aerovox Capacitance and Resistance Bridge measures capacitance from 100 $\mu$fd to 100 mfd, power factor from 0 to 50%, resistance values from 10 ohms

to 1 megohm in 5 ranges, insulation resistance from 350 megohms to infinity at 500 volts and down to 10 megohms at lower voltage. It provides a vacuum-tube voltmeter, choice of voltmeter, millivoltmeter and milliammeter for external uses, as well as a continuously variable power supply of 15 to 600 volts for internal and external uses. For testing electrolytic condensers, instrument provides polarized voltage; indicates applied voltage and leakage current at any moment. Full 270° main capacity dial scale is linear, covers one decade per range.—*Aerovox Corporation, 70 Washington St., Brooklyn, N. Y.*

## Oscillograph Pickups

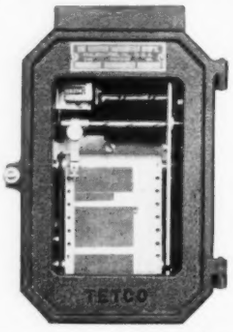
Oscillograph pickup units for sound, vibration, impact, heart-beat and other phenomena, include the following: (1) For studying sound, Type 108-M bullet-shaped dynamic microphone of special high impedance; (2) For highly localized sounds such as an engine noise, a small lapel crystal microphone; (3) For vibration studies and measurements, Brush inertia type delivering voltage proportional



to acceleration received when applied to a vibrating body, acceleration being proportional to the product of amplitude and square of frequency. Large vibration amplitudes cannot harm this pickup. One model covers frequencies up to 1500 cycles per second, and a second up to 5,000 cycles; (4) For vibration studies and measurements, Brush displacement type delivering voltage directly proportional to amplitude of motion and independent of frequency in its linear range, so that frequency and harmonic content of generated voltage are identical with that of the observed vibration, which is preferred for low-frequency work; (5) Stethoscope or heart-beat pickup.—*Allen B. DuMont Labs., Inc., 2 Main Ave., Passaic, N. J.*


**TETCO**

**Speed Recorder**




Creates a permanent time record on a waxed chart. Accurately records rate of production, time and duration of stops, total quantity produced.

**The Electric Tachometer Corp.**
1358 Spring Garden St., Philadelphia, Pa.

**Surface Temperatures**

Flat Stationary or Moving Curved Surfaces

**The "Alnor" Combination Pyrocon**

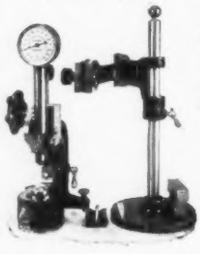
Ideal for rolls, molds, plates, platens and plastic material temperatures.

Write for bulletin.

**Illinois Testing Laboratories, Inc.**
142 W. Austin Ave. Chicago, Illinois

**HARDNESS TESTING...**

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 30 years.



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**RHEOSTATS**
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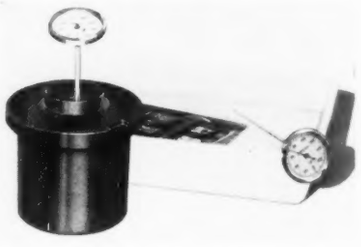
## Photographic-solution Dial Thermometer

New model of stainless-steel-stem dial thermometer (see *Instruments*, Feb. 1938, page 56) employing sealed internally-balanced bimetallic double coil (see



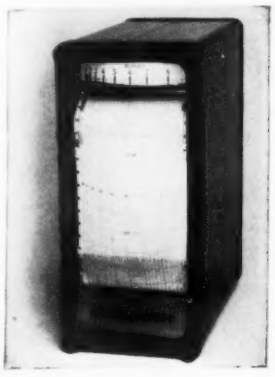
*Instruments*, Nov. 1935, page 305) has been developed for dark-room use. Dial scale, 0-180°F., can be easily read under dim safelights. Bimetallic element is sealed in lower 1½" of 8" stem, with 2" immersion, accuracy of ±1° throughout scale is guaranteed.—*Weston Electrical Instrument Corp., 591 Frelinghuysen Ave., Newark, N. J.*

## Ignition-lag Indicator for Diesel Fuels

Developed for determining the ignition quality (cetane number) of Diesel engine fuels, Aminco Penn State Ignition Lag Indicator is said to have an inherent accuracy greater than one-fourth cetane number. With it, the ignition quality of 10 to 15 fuels per hour can be determined. Thus it is more reliable than the bouncing-pin method and about ten times faster. It is supplied to fit the standard Waukesha C.F.R. Diesel Test Engine and can be installed in about one hour by average operator. Method consists of injecting fuel at a given time before top center, and adjusting compression ratio to give ignition at top center. Indicator consists of magnetic pick-ups for detecting injection and ignition impulses; a double thyratron relay for converting these impulses into surges; and a neon protractor mounted on the flywheel and bearing two neon lamps (set at a known angular distance from each other) to convert impulses into a visual signal.—*American Instrument Co., 8010 Georgia Ave., Silver Springs, Md.*

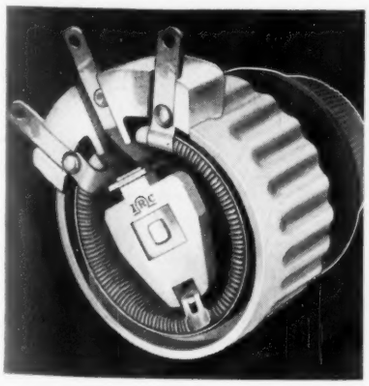
## Recording Instruments

New "G-40" recording instruments are available with movements and charts to meet all conventional requirements in central station and industrial fields. Measuring elements, all of direct-acting type, are of integral design: one frame carrying all moving parts including electromagnetic damping mechanisms. D-c. voltmeter, ammeter, millivoltmeter and milliammeter movements are permanent-magnet moving-coils; single phase wattmeter, voltmeter and ammeter elements are iron-clad iron-core single-element dynamometers. These movements have high torque-weight ratios, nominal volt-ampere burdens and good frequency performance. Polyphase wattmeter and varmeter movements are double-element dynamometers. Varmeters are furnished with phase-shifting compensators to provide the necessary quadrature voltages where required. Chart mechanism assembly is rigidly supported between two $\frac{1}{8}$" thick brass plates; synchronous and spring-driven clocks are interchangeable; paper speeds are changed by substituting one gear; a friction clutch is provided for chart timing adjustment; direct-drive reroll spool has low-friction ball bearing. Housing is surface-mounting style, to which portable carrying details may be added. Standardized centralized terminals are furnished with switchboard mounting recorders.—*Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*

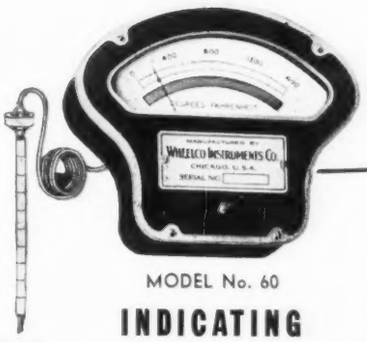


## "All-metal" Rheostat

Safe operation at full 25-watt rating down to 25% of full rotation with a temperature rise of about 160°C. is possible with new "IRC Type PR-25 All-Metal" 25-Watt rheostat, though its diameter is only $1\frac{31}{32}$", due to its heat-dissipating, all-metal construction. Resistance element is formed of low temperature coefficient wire uniformly wound on an asbestos-insulated strip of heat-dissipating aluminum core.—*International Resistance Co., 401 N. Broad St., Philadelphia, Penna.*





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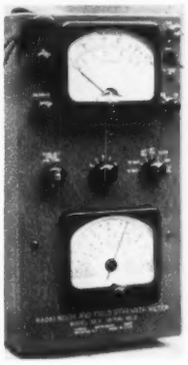
## Noise and Field Strength Meter

New "Model 32" is said to be "the first compact, portable, and accurate radio-frequency microvoltmeter" for noise surveys, field intensity surveys, measurements of noise voltages on lines and conductors, testing of electrical equipment, filter design, localization of noise sources, etc. Frequency range, 150 to 350 and 550 to 20,000 kc; voltage range, 1 to 100,000 $\mu$v (100 db); field intensity, 2 to 200,000 $\mu$v. volts per meter with antenna supplied. Dimensions 7" × 12½" × 9". Weight with batteries 20 lbs. Among novel features are (1) A self-contained calibrating generator enabling user to gain-calibrate his noise meter, thus making possible measurements instead of comparisons. (2) Logarithmic scale of output meter covering three decades, from 1 to 1000 $\mu$v. volts (60 db), whereby the controls seldom need to be touched: "when the field becomes very strong, one operation changes the meter range by a factor of 100." (3) Adaptability: "Model 32" can be operated from dry batteries for portability, from a vibrator pack for mobile use, or from 115-volt line indoors. Changeover "is a matter of seconds."—*Ferris Instrument Corp., Boonton, N. J.*



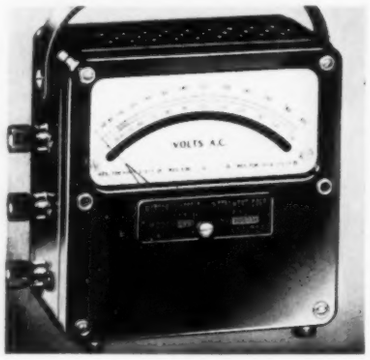
## Footage Registering Devices for Vehicles

Said to give results almost as accurate as surveyor's steel tape, "Survey Footometer" is a fifth-wheel outfit easily attached to any car without using tools. Principal parts are a bicycle type wheel and tire held in contact with the ground by a coil spring; a dial type register with zero-reset feature and with largest dial graduated in feet; a drive cable in two sections; attachment brackets, etc. Accuracy is said to be obtained by using a standard bicycle balloon tire (24x2.125) "at practically no air pressure" to prevent bouncing of wheel.

There is also announced a "Footometer" for attachment to the speedometer drive of any car—which is desirable, for example, when required to take land measurements unobserved. This outfit is supplied with an adapter having a gear ratio to suit the make of car but the user can exchange this adapter for one with a slightly different ratio if he finds, when driving over an accurately-measured mile, that the dial registration is not exactly 5280.0.—*Speedometer Service Co., 131 Fell St., San Francisco, Calif.*

## Temperature-Compensated Voltmeters

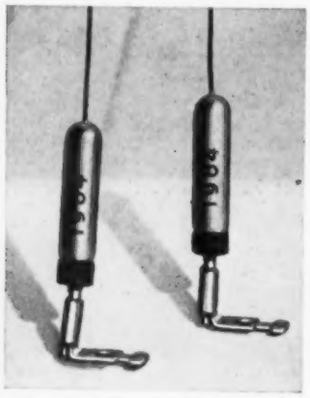
Two new "Model 433" portable multirange a-c. voltmeters have improved temperature compensation of particular benefit in public utilities' field test work

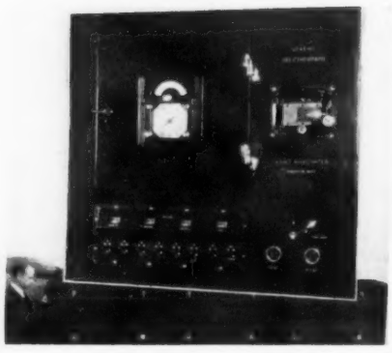



at temperatures ranging from —20° to 120° F. Double-range (300/150 volts) and triple-range (600/300/150 volts) instruments are available with temperature error of 1% for 60° C. (140° F.) on 150-volt and 300-volt ranges and 1% for 240° C. (464° F.) on the 600-volt range. Due to the special internal connections, new instruments have range-changing switches, but otherwise are similar in general specifications to other "Model 433" a-c. portables. — *Weston Electrical Instrument Corp., 591 Frelinghuysen Ave., Newark, N. J.*

## Liquid-dielectric Fixed Capacitors

"Liquid Compensator Condensers" are said to be of a type which shows an extremely accurate and readily measured decrease in capacity with rise in temperature. From 0.5 to 2 Mc., the $C/Q$ ratio is about 0.04 for Type No. 1 and about 0.05 for Type No. 3. Two types cover a capacity range of 5 to 9.5 mfds., negative drifts for a 30° C. rise of 0.1 to 1.6 mfds. An intermediate type is also obtainable on special order. Overall length $1^{3}/_{8}$" (not including wire lead); metal containers $^{1}/_{4}$" diam. — *Sprague Specialties Co., North Adams, Mass.*





## Three-Meter Grating Spectrograph

New Model S-2 is similar to the earlier one (*Instruments*, Oct. 1937, page 258) so far as optical arrangement is concerned, but all controls have been motorized, resulting in a more compact construction with no loss in accuracy of setting. All adjustments are made from panel end (see inset view in illustration). Any part of the spectrum in any order may be placed on a single plate and as many as 30 spectra may be taken on one plate. Switches for setting calibration points allow motors to be run forward or backward, fast or slow. Electrical racking permits moving plate holder steadily to record spectra continuously for determining when the various constituents of the source burn themselves out. Plate holder dark slide is closed at all times when plate holder is out of rack, automatically opens for successive exposures. Any plate up to 4"x10" may be used. A spectral line mask controlled from front panel allows spectra up to 15 mm. high to be recorded, permitting superposition of known or unknown without racking. No stray light can strike photographic plate, except negligible amount scattered by ruled area of grating. Speed of instrument compares favorably in the first order with that of a large quartz instrument. Dimensions 24" × 22" × 132"; weight about 800 lbs.—*Baird Associates, 20 Palmer Street, Cambridge, Mass.*

## Plate and Filament Transformers

A complete new line of "Low Cost Plate and Filament Transformers" said to "embody high efficiency, low regulation, and heavy-duty designs incorporating low temperature rise," comprises three separate groups: (1) plate-filament transformers for use in conjunction with all latest tubes; (2) filament transformers; (3) filter reactors. In this last group each reactor is double wound so that it may be connected in series or parallel thus obtaining either of two different values of inductance and current in the same unit. All components are supplied in the new Ferranti through-type reversible case (see *Instruments*, May 1936, page 123) for either top or sub-panel mounting. Cases are of folded steel with heavy solder lug or porcelain terminals.—*Ferranti Electric, Inc., 30 Rockefeller Plaza, New York City.*

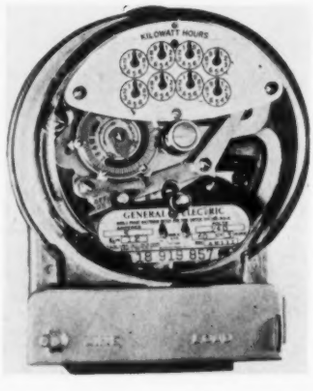
## Temperature-Compensated Voltmeters

Two new "Type AP-9" a-c. voltmeters with temperature compensation are expected to find their major applications in voltage-survey work. New 150-volt

instrument has a temperature coefficient of not more than 1% for 100° C. (180° F.) so that, being calibrated at 70° F., its error at 0° F. (—17.8° C.) will not be more than 0.7 volt. New 150/300-volt instrument has the same coefficient (0.01%) when used on the 150-volt tap and 0.015% when used on the 300-volt tap. Thus both are accurate to 0.5% throughout the 75- to 150-volt portions of their scales. It is said that remainder of scale, in each instrument, "maintains standard accuracy of 0.75%." —*General Electric Co., Schenectady, N. Y.*

## Combination Watthour Meter and Time Switch

Recently-developed Wide Limit watthour meter (see *Instruments*, Dec. 1937, page 300) and an improved Telechron-motored time-switch register are combined in the new "IR-30" combination unit, affording savings in space, installation and maintenance costs, and inventory investment. Combination meter is available in all ratings, with any one of three registers: single-dial, with contacts; double-dial with contacts; and double-dial without contacts. It is available for front connection or for socket mounting. —*General Electric Co., Schenectady, N. Y.*



# Ford Power Plant Instrumentation

## IV—Instrumentation of Condensers, Heating System, Blowers, etc.

By W. W. DULMAGE

Power Department, Ford Motor Co., Dearborn, Mich.

### CONDENSER INSTRUMENTATION

INASMUCH as the preceding article confined itself to instruments on the turbo-generators proper, the instrumentation of the condensers will first be described in this article. On each board there are twelve gages, two recorders and a signal system, as follows:

Two gages indicating steam pressure (225 lbs.) before reducing valves to two Worthington steam-air ejectors on the north and south sides of the condenser.

Two gages indicating steam pressure (160 lbs.) after reducing valve to Worthington steam-air ejectors on north and south sides.

Pressure (62 lbs.) on "mill water." This water is used in the oil coolers, seals on circulating pumps and bearings on condensate pumps.

Two gages indicating condensate discharge pressure (52 lbs.).

Seal water pressure—the pressure (36 lbs.) on condensate used as pump seal on certain auxiliaries. This is the head of water between seal water tank (located on 5th floor) and condenser pit.

Pressure of steam to low-pressure heater (20" hg.)

Pressure on discharge side of low-pressure heater. *Note:* This condensate is recorded and integrated by a Bailey meter, then pumped into main condensate line, on supply side of deaerator. (This Bailey meter is not located on the panel board, but on a wall.)

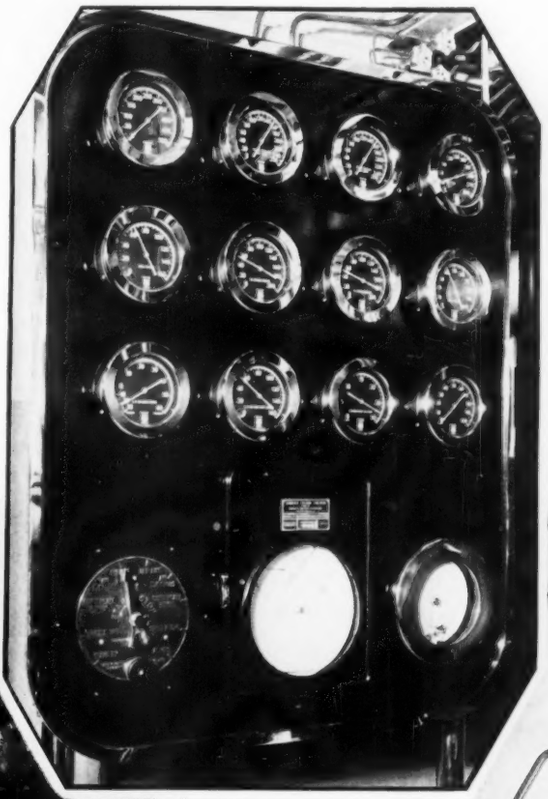
Vacuum gage indicating vacuum in the condenser.

Pressure gage indicating seal pressure (350 lbs.) on boiler feed pumps. This pressure is created by a Worthington triplex power pump located in condenser pit. This seal water picks up heat in pump glands. Leaving the pump glands, the water flows to a flash tank, thence to main condensate line.

This makes a total of twelve indicators.

The Bailey meter (lower center) records water level in surge tank and clear water tank, probably better known as the North Hot Well. Excess water is stored in the surge tank. The operating principles of our Bailey meters have been described in preceding articles.

At the lower right is an instrument recording atmospheric and condenser pressures. Known as the Uehling



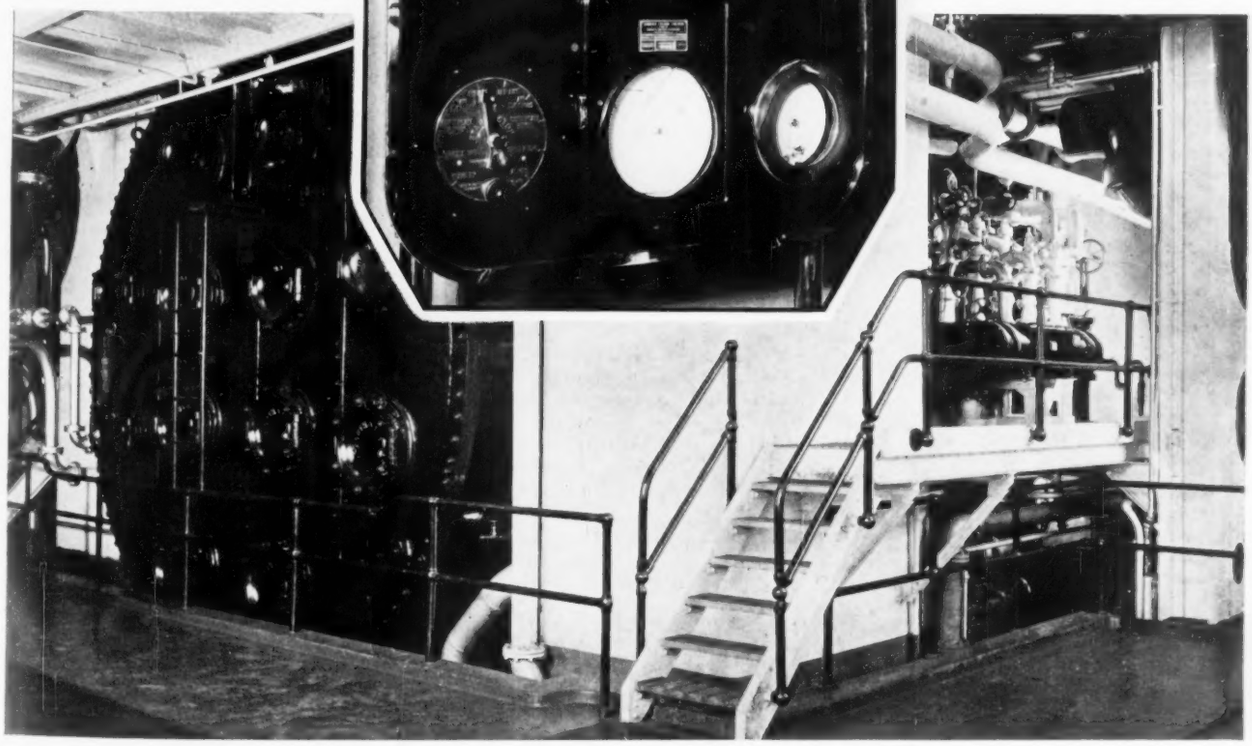


Fig. 1. Condenser on No. 1-2 unit

Fig. 2 (inset). Panel board for No. 1-2 condenser

Combined Vacuum and Barometer Recorder, it consists essentially of two float chambers, contained in a float vessel. One float chamber is connected with a barometric mercury column and the other with a vacuum mercury column in communication with the condenser system. The pens are moved up and down by means of floats which rest on the surface of the mercury in the two chambers and a guide rod passing through each float prevents side motion. The pen movements correspond, therefore, to the changes in barometric pressure and vacuum.

A Selsyn signal system (lower left) concludes the instrumentation of each large condenser. This signal system was described in the preceding article.

The panel board just described is on the condenser of No. 1-2 unit. On No. 3-4 condenser board the only difference is that the indicating vacuum gage has been eliminated, the Uehling performing the complete job.

On both the large units the condensate, leaving the condensers, passes through a series of heat exchangers and for all practical purposes these are as follows: (1) steam-air ejectors; (2) generator air coolers; (3) low-pressure heaters; (4) flash tank condenser; (5) deaerator; (6) cross-over heater; (7) high pressure heater. Temperature rises are measured by indicating thermometers set in wells after each heat exchanger.

The condenser on each unit is also equipped with two alarm signals:

(1) Hotwell High Level alarm, which sounds off when water level in hotwell of condenser rises to a pre-determined level.

(2) Water box alarm sounds off when circulating water in water box falls below a safe operating level.

## HEATING SYSTEM PANEL BOARD

ON the main floor, directly south and in line with the booster and boiler feed pumps is located No. 1 Heating Station, comprising one high-pressure Croll Reynolds heater and four low-pressure Alberger heaters with accompanying circulating pumps and accessories. The heating system supplies hot water to the Production Foundry High Line, "E" Building (Locomotive Shop), Blast Furnace, Pulverizer Building and also takes care of the Motors Building in mild weather. Fig. 3 shows the panel board for this station. On the panel board are eight pressure gages indicating the following: (1) 125-lb. steam line pressure; (2) north main steam line pressure; (3) south main steam line pressure; (4) 150-lb. steam line pressure; (5) heating system return pressure; (6) altitude gage (feet of water); (7) exhaust or vapor pressure; (8) heating system discharge pressure.

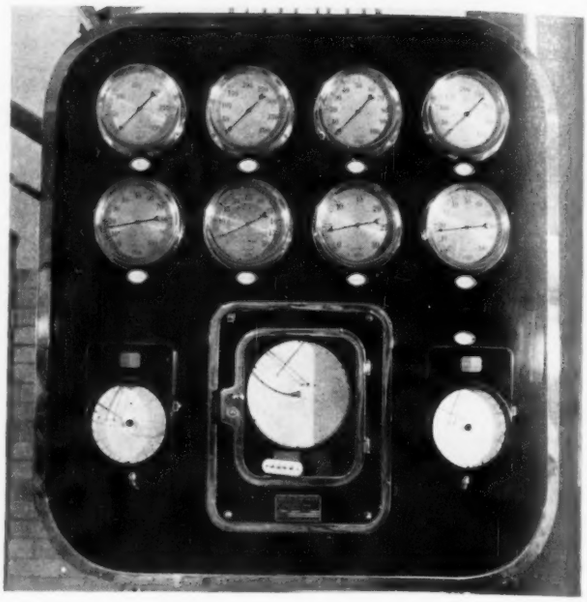


Fig. 3. Heating System Control Board

A Bristol recording thermometer (lower left) records temperature on discharge side of circulating pumps.

A Bailey flow meter (lower center) records flow of condensate from heaters.

A Bristol recording thermometer (lower right) records temperature on hot water return line.

Circulating pumps are run at a constant speed and temperature maintained by increasing or decreasing the amount of live steam admitted to the hot water heaters.

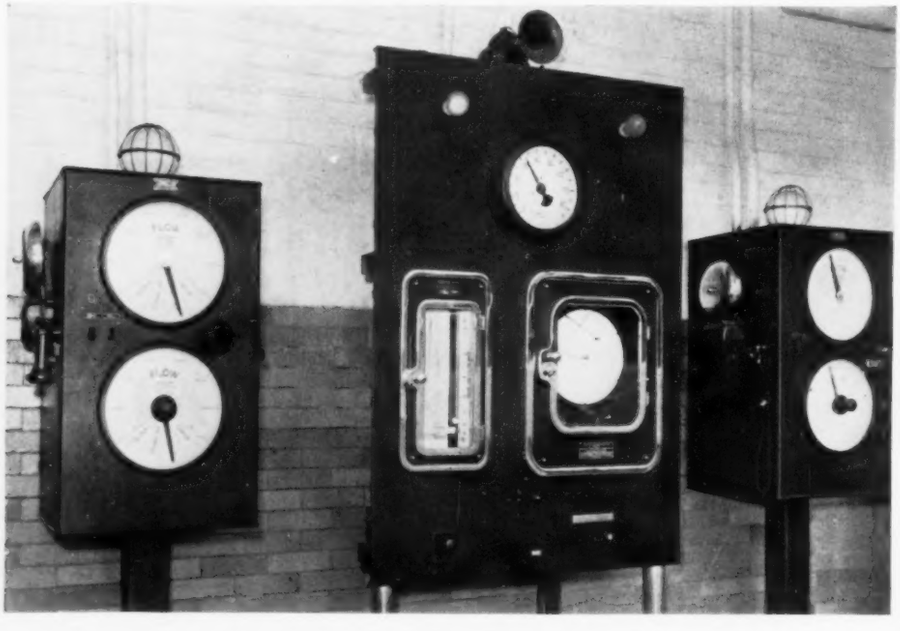


Fig. 4. Central Blower Control Station. NOTE—Each turbo-blower set has also an instrument board (not illustrated).

## BLOWER ROOM INSTRUMENTATION

IN a large room known as the Blower Room, we have three compressor sets supplying air to two 750-ton blast furnaces which normally require 44,000 cubic feet per minute per furnace. These sets are described as follows:

*Unit No. 2.* General Electric 40,000 cfm. @ 27 lbs./in.$^2$ 200° F. blower, driven by a 4500-hp. 3600-rpm., 40-stage 200 lbs./in.$^2$ condensing General Electric Turbine.

*Unit No. 3.* General Electric 70,000 cfm. @ 30 lbs./in.$^2$ 250° F.

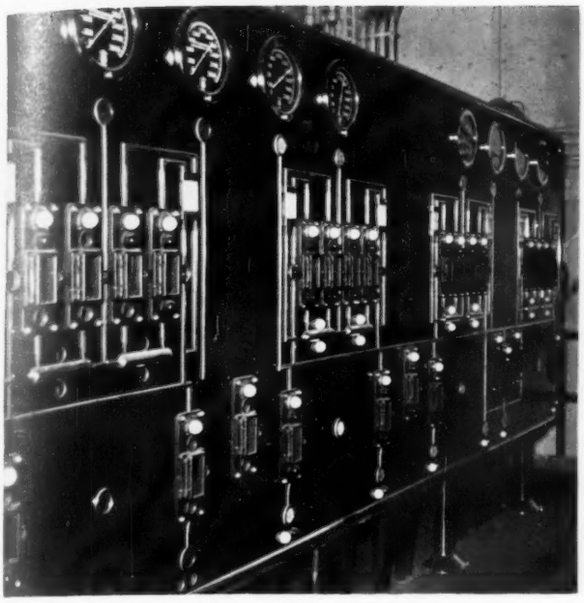


Fig. 5. Feed Water Distribution Panel on Water Deck

blower, driven by a 7900-hp. 10-stage, 4100 rpm. 225 lbs./in.² condensing General Electric Turbine.

*Unit No. 4.* Same as No. 3.

Each turbo-blower set is equipped with the following instruments:

(1) A Bailey steam flow meter recording and integrating flow to unit.

(2) Selsyn signal system consisting of the following: (a) Selsyn indicator and transmitter; (b) three bell switch; (c) telephone.

(3) Gage board (on turbine proper) consisting of the following: (a) mercury column indicating barometric pressure-condenser vacuum column; (b) steam pressure gage; (c) first stage pressure gage; (d) jet pressure gage; (e) air pressure gage (blower); (f) vacuum gage (compound); (g) steam seal pressure gage.

(4) A Bailey meter recording flow and pressure of air from blowers.

(5) Indicator and liquid column, indicating air volume output of blowers.

(6) Thermometers on inlet and outlet sides of circulating water and oil systems.

As previously mentioned, these blowers are located in the Power House, which is several hundred feet from the Blast Furnaces. However, through a remote control system, the furnace operator has complete control of wind supplied to each furnace. If the furnace operator desires to make a change in volume supplied, he does so through a Selsyn transmitter already mentioned or through a horn-Selsyn indicator signal system.

## FEED WATER DISTRIBUTION PANEL

ONE of the latest developments in control boards in No. 1 Power House has been the installation on the water deck of a board on which is laid out in detail the feed water distribution system to the high-pressure boilers.

On this board (partly shown in Fig. 5) are remote controls operating the valves on the feed lines to the various boilers. Complete motorized control is available to division valves, both between boilers and feed pumps and also drum valves. High and low water alarms are connected to this board both by light and horn. An alarm also sounds and is also indicated by lights if the motor fails on the Selsyn-operated Bailey feed water control valves of each boiler.

Light signals are as follows: On Valves: (1) White lights indicate power on; (2) Red lights indicate valve is open; (3) Green light indicates valve is closed. On Drums: White light indicates normal operating condition; On high or low water conditions this same light flashes on-and-off, and a horn also blows.

In case of feed water trouble the water tender can immediately tell which boiler is in difficulty and also source of trouble and can, if absolutely necessary, make adjustments to correct the difficulty. The water tender is further aided by gages indicating feed water pressure and steam pressure on each boiler.

## LUBRICATION SYSTEM INSTRUMENTS

PROPER lubrication is extremely important to all machinery having moving parts; and turbo-generators are no exception. Since gages and thermometers have such an important part in proper lubrication, they have been installed at numerous points throughout the plant where oil pressures and temperatures are desired to be checked.

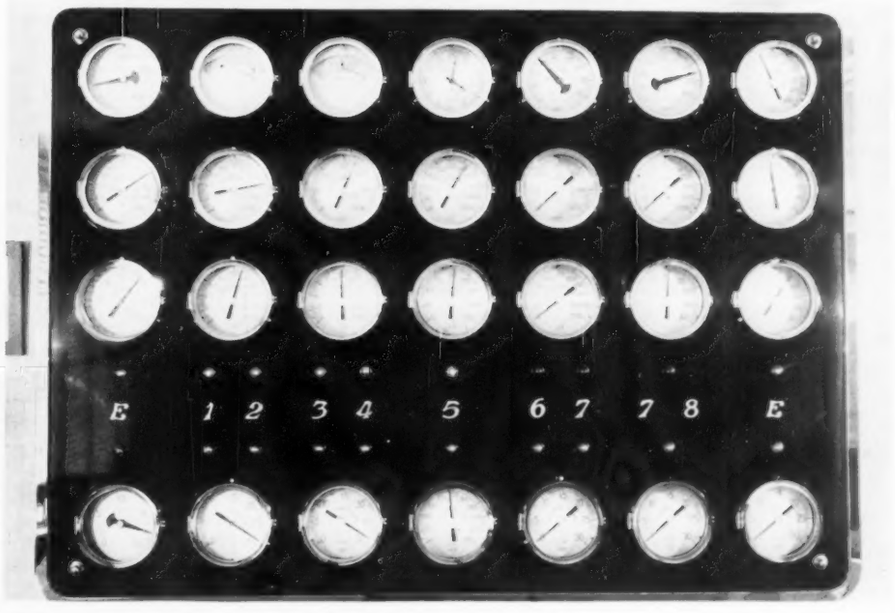



Fig. 6. Master Indicating Panel in office of W. W. Dulmage.

*Upper row:* (1) Megawatts 0-400; (2) A-C. volts 0-1500; (3) Frequency 50-70; (4) clock; (5) air flow No. 3 blower 0-85,000 cfm; (6) No. 4 blower ditto; (7) 200-lb. steam service line pressure 0-500.

*Second row:* (1-6) Boiler feed and booster pump pressures, 0-1000, 0-1200, 0-2000 and 0-2500; (7) low-pressure steam 0-500.

*Third row:* (1) air pressure 0-150; (2, 3 & 5) generator header pressures 0-2500; (4) city water 0-160; (6) mill water 0-160; (7) low-pressure feed water 0-500.

Two rows of bull's eye signals.

*Bottom row:* (1) Surge tank level 0-20 ft.; (2, 3, 5, 6 & 7) turbo-generator condenser vacuum 0-30"; (4) exhaust No. 5 non-condensing turbine 0-500.

# Indentation Hardness Testers *(Continued)*

By S. R. WILLIAMS
Professor of Physics, Amherst College

THE MONOTRON

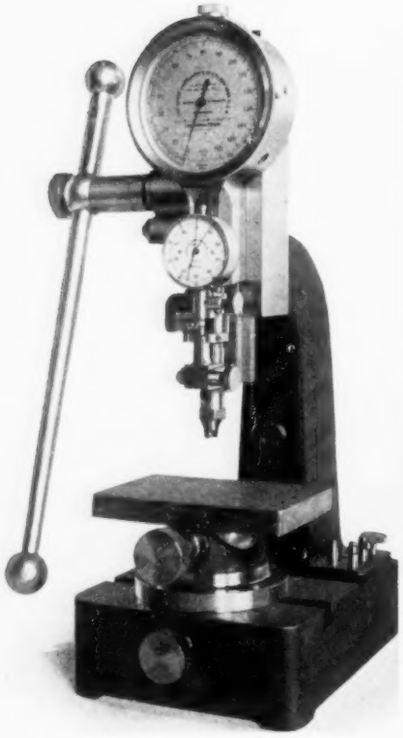
The basis for the operation of this instrument (Fig. 143) rests on the proposition that hardness can be measured by the load required to produce a definite penetration of the material under test. This may be established as the load necessary to give a constant diameter of imprint, or a constant depth of imprint. "It is," as Bĕhar[1] has said, "all a question of definitions: if any body of men proclaims that hardness is the diameter of a ball's impression, the angle of a pendulum's rebound, the force to produce a given impression, or what not, it is just that—as far as that body of men is concerned." For the same indenter a constant depth will mean a corresponding constant diameter of imprint. This same relation holds for the various scratch methods. Among scratch instruments the Graton[2] machine made use of the idea that the load which gave a predetermined scratch width could be utilized as a measure of hardness, while the width of cut with constant load was employed in measuring hardness with the Bierbaum[3] Standard Instrument. The Graton type of scratch tester corresponds to the Monotron, *i.e.*, in using a varying load and constant dimension of the imprint. The Bierbaum instrument has its counterpart in the Brinell hardness tester with its constant load and varying dimensions of indentation.

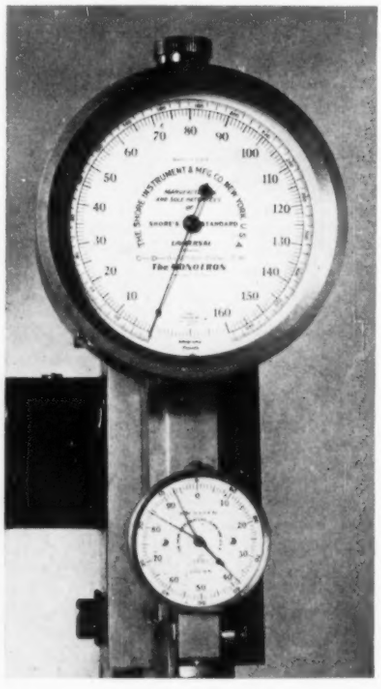
*Procedure in measurement.*—In making a hardness test with the Monotron, a "penetration is first made to a predetermined standard depth by aid of a compensated depth micrometer indicator." The hardness number is then read from the pressure gage ordinarily in terms of kilograms per unit area, while the load is still on. In Fig. 144 are shown the pressure and depth scales: the upper dial gives the load, the lower one the depth of imprint.

The depth of indentation is measured while the load is still on the indenter, because this procedure avoids any confusion which might arise from elastic after-effects. It also offers a means for testing materials other than metals, such as hard rubber, compositions, minerals and vitreous compounds. If the applied load is removed, elastic recovery sets in and the depth indicator returns toward zero. The reading of the depth indicator, after elastic recovery has occurred, is a measure of permanent deformation.

If the standard depth of penetration is exceeded, both ductility and point of plastic flow of the softer metals and compositions may be studied and evaluated. Also the effect of time, which is of importance under overload conditions, may be readily observed.

[1]M. F. Bĕhar. Editorial note in *Instruments*, Vol. 7, July 1934, page 134.
[2]See discussion of this scleroscope, *Instruments*, Vol. 10, September 1937, pages 237-238.
[3]See discussion of this scleroscope, *Instruments*, Vol. 10, November 1937, pages 286-288.





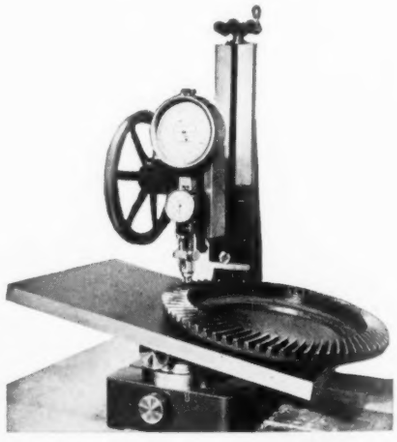


Fig. 143. Model "A" Monotron.

Fig. 144. The lower dial shows the Monotron depth gage provided with twin pointer hands used for making high-speed tests in production work. This method makes it unnecessary to set the gage to zero. The entire test is made by a single stroke with the left hand on the ball lever, leaving the right hand free to handle the work. The upper dial records the load applied in order to give a predetermined depth of imprint.

Fig. 145. Monotron model "C" equipped with special large tilting table for testing large pieces.

Fig. 146. By a single movement of the ball-ended lever the operator applies the load to the indenter.

*Monotron Scales.*—There are several scales for the Monotron instrument, depending upon the size of the penetrator. Thus the standard test is made with a hemispherical diamond impresser, the diameter of which is 0.75 mm., and the established depth to which the spherical surface is sunk is 9/5000 of an inch. Scale (M-1), used for this combination of indenter and depth of impression, reads directly in kilograms and Brinell units. Such a combination of indenter and depth of impression allows a wide range of hardness to be tested without special compensatory adjustments of the machine or changing of points.

However, there are furnished with each machine larger hemispherical indenters which are made of cemented tungsten carbide of special quality and come in sizes of 1/16″ and 2.5 mm. in diameter. The scales which go with these indenters are referred to as the (M-3) and the (M-4) respectively. It is possible to have made to order an indenter 1 mm. in diameter. It is not in common use, but when used the scale is known as the (M-2) scale.

In all of these scales the same predetermined depth of penetration, 9/5000 of an inch, is used.

*Operation of the machine.*—The specimen to be tested is placed firmly on the test table or directly on the bed plate of the machine. In Fig. 145 is shown the way in which the test table may be tilted in order to bring the surface of the test piece into proper position for the measurement of its hardness. By means of the ball lever as shown in Fig. 146 the measuring head is brought down until the work contact cup begins to move the depth indicator hand. When this comes to rest the ball lever is stopped and the depth gage is set to zero. The indenter is just ready to contact the test piece. Then the load is further increased until the hand on the depth gage has traveled the standard nine divisions or a penetration of 9/5000″ has been made by the diamond indenter. When this indentation has been made the pressure gage is read to determine what load in kilograms was necessary to give this standard indentation of 9/5000″, and this load in kilograms serves as a hardness numeral on the Monotron hardness tester.

In Fig. 147 is shown a twin hand for the depth gage. Many find it easier to observe the swinging of the hand *B* to the position *A′*, the position occupied by *A*, than to count the nine divisions over which a single pointer moves. Each division on the depth gage scale represents 1/5000″ and when the pointer *B* moves to the position occupied by *A* the hand has turned nine divisions—the interval between the twin hands *A* and *B*. With a little practice this double hand makes the observation of the depth reading an easy one. The twin hand also obviates the necessity for a zero setting of the pointer on the depth gage. After reading the pressure gage, while the load is still on, the ball-ended lever removes the load from the indenter and returns the instrument to conditions ready for another observation. The Monotron is standardized and checked up with the standard test blocks without any pre-pressure. In this case the blocks lie smoothly on the test table and with the upper surface normal to the force put on the indenter. Under certain conditions it may be desirable to put on a pre-pressure. This occurs when the surfaces are irregular or rough. Under such conditions the pre-pressure helps to hold the specimens against slipping during the test. The order of procedure, after pre-pressure is applied, is the same as for the standard test.

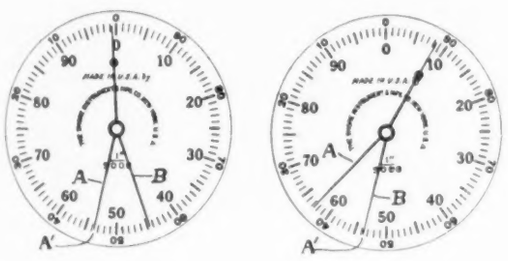



Fig. 147. The twin depth hands, A and B, are set so that their points are 9 scale divisions apart. Since each division represents 1/5000″ of penetration of the indenter, the swinging of the point of B to the position of the point of A gives the standard indentation of the Monotron. This swing is read more easily than to count nine divisions over which a single pointer moves.

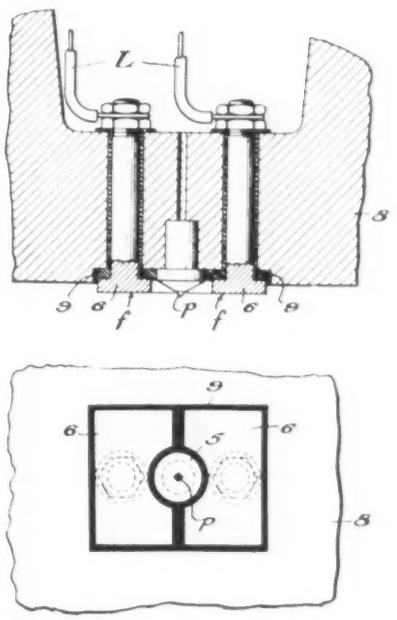



Fig. 148. The main element in the method devised by DeLeeuw for measuring hardness.

The Monotron has a great deal of flexibility in that one may disregard the depth gage and by means of a microscope measure the diameter of the impression for a predetermined load (say 150 kilograms) and thus use the instrument as a Brinell hardness tester.

### DE LEEUW'S METHOD

The basic principle of the Monotron is that an impression of fixed size is made and the force required to make this impression is taken as the measure of the hardness of the material being tested.

Another machine which makes use of this principle is one suggested by De Leeuw[4]. Not only does this machine work simply but it also makes a permanent record of the reading.

In making a reading the sample to be tested is laid on a table supported by a hydraulic piston. As the piston moves upward, being driven by a motor-driven oil-pump, the surface of the specimen is forced against a pointed diamond or a small steel ball. The steel ball will be preferred for the softer materials. The diamond point or the steel ball (*p*., Fig. 148) projects down a certain predetermined distance, about 0.005″, between two small hardened anvils (6,6), the faces of which lie in a common plane (*f*,*f*). The anvils are electrically insulated (9.9) and constitute portions of a low voltage

[4]A. L. DeLeeuw. A New Method of Hardness Measurement. *Instruments*, Vol. 7, 1934, pages 134-135.

battery circuit. The moment the depth of penetration, 0.005″, is reached the surface of the metal tested makes a short circuit between the faces of the two anvils and an electric bell or other signaling device notifies the operator that the proper depth has been attained.

The piston carrying the table on which the specimen rests is actuated by oil under pressure. The pressure which is applied to the oil also drives a small piston in a smaller but longer cylinder. This piston acts against a calibrated spring and carries the terminals of a spark gap. At the moment the short circuit is made between the two anvils another transformer steps up the voltage and causes a spark to jump between the terminals of the spark gap and make a tiny perforation in a sheet of paper on which the height of this puncture above the zero line of the calibrated chart gives a measure of the force applied to give the proper penetration.

The machine is provided with a number of automatic features. When a new piece of work is laid on the working table of the instrument, all one has to do is to push a button which then starts the motor on a new test cycle.

### LUDWIK'S HARDNESS TEST

Reference has already been made to the cone-shaped indenter and the application of the general formula that

$$\text{Hardness} = \frac{\text{Load}}{\text{Area of imprint}}$$

Ludwik[5] chose a cone-shaped indenter with an angle of 90° in an attempt to overcome the discrepancies between the Brinell hardness numbers as obtained with different sizes of balls and loads. The cone indenter is a form frequently found in use on the continent in measuring the hardness of soft materials. In thus selecting an angle of 90° for the tip of the indenter, Ludwik made the depth and the diameter of the imprint to have the same value. At first he used a sharp 90° hard steel cone and determined his hardness number from the surface contact area of the recovered indentation.

Ludwik's hardness number:

$$\text{"Cone Hardness"} = \frac{\text{Load}}{\text{Conical contact area}} = \frac{\text{Load}}{\frac{4L\sin(\phi/2)}{\pi d^2}}$$

where in Ludwik's cone, $\phi = 90°$ and $d$ is the diameter of the imprint. If the material is homogeneous, the Ludwik hardness number remains consistently the same irrespective of the size of imprint and load.

*Application of Ludwik's Cone to the Measurement of Hardness with Change of Temperature.*—Ludwik was primarily interested in a study of the internal friction[6] of metals. He pointed out that a great deal had been written about the internal friction or viscosity of liquids but little concerning solids. Inasmuch as Ludwik was interested in the problem of hardness he conceived the idea that internal friction of metals would in some way or other be measured by the permanent deformation produced by a hardness tester, and so proceeded to use his cone indenter for this purpose. He chose the cone indenter for this study because, due to the geometrical similarity of the imprints, the hardness numbers obtained are independent of the magnitude of the load used and of the size of the imprint. Furthermore, in the case of a hardness tester in which a constant load is used, there will be dissimilar conditions of deformation. This

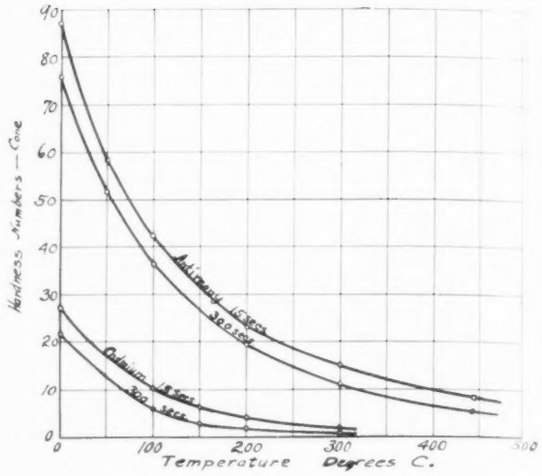



Fig. 149. Change of hardness with temperature.

may lead to wide discrepancies when one is dealing with large differences in hardness, and this would be the case in Ludwik's work where the range of temperature was from room temperature up to the melting point for some metals and on to 600° C. for others.

Ludwik measured the change in hardness (internal friction) with temperature for tin, bismuth, cadmium, lead, zinc, antimony, aluminum and copper.

The heating chamber in which the sample was maintained at any desired temperature was closed with a poor heat-conducting cover through which there extended a carbon rod carrying the indenter. In this fashion the indenter could be moved to various points on the surface of the test piece and the cover would slide sidewise and allow for this motion of the indenter. The carbon rod carrying the cone indenter was selected because it would not conduct heat so rapidly from the test point as would a metal rod and thus give no chance for local cooling at the point of test.

The length of time during which the load was left on the indenter made a large difference in the results for some of the metals tested. The longer period made a deeper impression and, therefore, the hardness number was smaller. Periods of 15 and 300 seconds were employed. Fig. 149 shows the results for cadmium and antimony. At 200° C. the hardness for the 15-second period was twice that for the 300-second period. Both for cadmium and for antimony it will be noted that the hardness curve for the 300-second period is always less than for the 15-second period. The changes for antimony are quite different from those in cadmium. In fact some of the other metals showed quite different curves from those indicated in Fig. 149.

The net results, however, show that the decrease in hardness with rising temperature is a continuous one. The discontinuities which one might expect in allotropic transformations did not show up in any pronounced fashion. While iron was not studied, one might expect a discontinuity in the course of the change of hardness with temperature as the latter passed through one of its transformation points.

Although this work of Ludwik was done over twenty years ago it is a good illustration of the kind of work which needs to be done in the field of hardness measurements. O'Neill[7] has brought together some of the more recent work which has been done along this and similar lines. There is a great deal more to be done.

[5] A. Leon, Über die Beziehungen Kegeldruckhärte zur Streckgrenze bei Eisen und Stahl, *Stahl und Eisen*, Vol. 27, 1907, pages 1820-1822; Also book review: E. Preuss, Vol. 28, 1908, pages 531-532.

[6] P. Ludwik, Über die Änderung der inneren Reibung der Metalle mit der Temperatur, *Zeitschrift für Physikalische Chemie*, Vol. 91, 1916, pages 232-247.

[7] H. O'Neill, The Hardness of Metals and its Measurement, Chapman and Hall, Ltd., London, 1934, pages 1-292 (See particularly pages 212-217, 220, 227, 238-245).

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Minn.-Honeywell Reg. Co.
Powers Regulator Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Thwing-Albert Instr. Co.
**Humidity & Temperature**
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
H-B Instrument Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Thwing-Albert Instr. Co.
**Humidity—Time**
Friez & Sons, Inc.
C. J. Tagliabue Mfg. Co.
**Lighting**
General Electric Co.
G-M Labs., Inc.
Pfaltz & Bauer, Inc.
Westinghouse E. & M. Co.
Weston Elec. Inst. Corp.
**Liquid Level**
American Meter Co.
Askania Regulator Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co
Friez & Sons, Inc.
General Electric Co.
G-M Labs., Inc.
Leeds & Northrup Co.
Powers Regulator Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.
**Moisture-content**
Askania Regulator Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
**Pressure & Vacuum**
American Meter Co.
Askania Regulator Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Hays Corp.
Minn.-Honeywell Reg. Co
Powers Regulator Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos
**Pyrometer**
Bailey Meter Co.
Bristol Co.
Brown Instrument Co
Charles Engelhard, Inc.
Foxboro Co.
Hays Corp.
Illinois Testing Labs.
Leeds & Northrup Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos
Thwing-Albert Instr. Co.
Wheelco Instr. Co.
**Rate-Volume**
American Meter Co.
Askania Regulator Co.
Cochrane Corp.
Foxboro Co.
C. J. Tagliabue Mfg. Co.
**Refrigeration**
Bristol Co
Brown Instrument Co.
Burling Inst. Co.
Foxboro Co.
Friez & Sons, Inc.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos
Thwing-Albert Instr. Co.
Wheelco Instr. Co.
**Specific Gravity**
Askania Regulator Co.
Bailey Meter Co.
Foxboro Co.
Pfaltz & Bauer, Inc.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
**Tachometer**
Bailey Meter Co.
Bristol Co.
Brown Instrument Co
Elec. Tachometer Corp.
Foxboro Co.
Leeds & Northrup Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.
**Temperature**
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Burling Inst. Co.
Cochrane Corp.
Charles Engelhard, Inc.
Foxboro Co.
Friez & Sons, Inc.
G-M Labs., Inc.
Hays Corp.
Illinois Testing Labs.
Leeds & Northrup Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos
Thwing-Albert Instr. Co.
Wheelco Instr. Co.
**Temperature-Time**
Bailey Meter Co.
Bristol Co.
Brown Instrument Co
Foxboro Co.
Friez & Sons, Inc.
Leeds & Northrup Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos
Thwing-Albert Instr. Co.
Wheelco Instr. Co.
**Time**
Bristol Co.
Brown Instrument Co.
Eagle Signal Corp.
Foxboro Co.
Friez & Sons, Inc.
General Electric Co
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Ward Leonard Elec. Co.
**Vacuum**
Askania Regulator Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
H-B Instrument Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
**Voltage A. C.**
Amer. Transformer Co.
Ward Leonard Elec. Co.
Wheelco Instr. Co.
**COUNTERS—Magnetic**
Durant Mfg. Co.
Veeder-Root Inc.
Ward Leonard Elec. Co.
**Revolution**
Bristol Co.
Brown Instrument Co.
Durant Mfg. Co.
Elec. Tachometer Corp.
Gaertner Scientific Corp.
Veeder-Root Inc.
**Stroke**
Bristol Co.
Durant Mfg. Co.
Eagle Signal Corp.
Veeder-Root Inc.

**CUBIC FOOT BOTTLES**
American Meter Co.

**CURRENT RECORDERS**
Bristol Co.
General Electric Co.
Leeds & Northrup Co.
Roller-Smith Co.

**CYCLE CONTROLLERS**
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

**CYCLE COUNTERS**
General Radio Co.
Westinghouse E. & M.Co.

**CYCLE RECORDERS**
General Electric Co.

**CYLINDER GAGES**
Federal Products Corp.

**DEMAND METERS**
**Gas**
Foxboro Co.
**Electric**
General Electric Co.
Westinghouse E. & M.Co.

**DEPTH GAGES**
Federal Products Corp.

**DIAL INDICATORS**
Federal Products Corp.
Testing Machines, Inc.

**DIVIDING MACHINES**
Gaertner Scientific Corp.

**DRAFT GAGES—See Gages**

**DYNAMOMETERS**
General Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.

**EARTH CURRENT METERS**
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.

**EBULLIOMETERS**
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.

**ELECTRIC TELEMETERS —See Remote Metering Equipment**

**ELECTRODES for pH**
G-M Labs., Inc.
Heilige, Inc.
Leeds & Northrup Co.
Natl. Technical Labs.
Pfaltz & Bauer, Inc.
Thwing-Albert Instr. Co.

**ELECTRONIC METERS**
General Electric Co.
General Radio Co.
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.

**EXTENSOMETERS**
Riehle Div. Am. Mach.
Testing Machines, Inc.

**FAULT FINDERS**
Leeds & Northrup Co.
Roller-Smith Co.
Rubicon Co.
Shallcross Mfg. Co.
Westinghouse E. & M.Co.

**FLASH & BURNING POINT TESTERS**
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

**FLOW METERS**
**Indicating**
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Fischer & Porter Co.
Foxboro Co.
Friez & Sons, Inc.
Pfaltz & Bauer, Inc.
Pioneer Instrument Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
**Indicating & Recording**
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Fischer & Porter Co.
Foxboro Co.
Friez & Sons, Inc.
Pioneer Instrument Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
**Integrating & Recording**
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Fischer & Porter Co.
Foxboro Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

**FLUE GAS ANALYZERS**
Brown Instrument Co.
Charles Engelhard, Inc.
Foxboro Co.
Hays Corp.
Leeds & Northrup Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.

**FLUXMETERS**
Leeds & Northrup Co
Rawson Elec. Inst. Co.
Rubicon Co.

**FOOT CANDLE METERS**
**See Illuminometers**

**FREQUENCY METERS**
**Indicating**
James G. Biddle Co.
Bristol Co.
General Electric Co.
Hickok Elec. Inst. Co.
Leeds & Northrup Co.
Roller-Smith Co.
Westinghouse E. & M.Co.
Weston Elec. Inst. Corp.
**Recording**
Bristol Co.
General Electric Co.
Leeds & Northrup Co.
Westinghouse E. & M.Co.
**Standards**
General Radio Co.
Leeds & Northrup Co.

**FURNACE ATMOSPHERE RECORDERS**
Brown Instrument Co.

**FURNACE CONTROLS**
Askania Regulator Co.
Bailey Meter Co.
Bristol Co.
Burling Inst. Co.
Foxboro Co.
Friez & Sons, Inc.
Hays Corp.
Illinois Testing Labs.
Leeds & Northrup Co.
Minn.-Honeywell Reg. Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos
Thwing-Albert Instr. Co.
Wheelco Instr. Co.

**GAGES**
**Absolute Pressure**
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
**Caliper**
Federal Products Corp.
Testing Machines, Inc.
**Cylinder**
Federal Products Corp.
**Depth**
Federal Products Corp.
**Dial Indicator**
Federal Products Corp.
Testing Machines, Inc.
**Differential Pressure**
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Hays Corp.
Pioneer Instrument Co.
Refinery Supply Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos
Thwing-Albert Instr. Co.
**Draft**
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Hays Corp.
Refinery Supply Co.
**Drill**
Bausch & Lomb Opt. Co.
**Electric**
General Electric Co.
**Flow—See Flowmeters**
**Grinding**
Federal Products Corp.
**Liquid Level**
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Hays Corp.
Leeds & Northrup Co.
Liquidometer Corp.
Pioneer Instrument Co.
Refinery Supply Co.
Republic Flow Meters Co
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.


**A & A COILS**

Magnet *Established 1924* Solenoid

Electrical Coil Winding Co.
2736 Saunders St., Camden, N. J.